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CUPOLA PRACTICE AND DESIGN.

By G. G. Ure.

The best types of cupolas vary very little in their principal features, and anything different may be interesting if as efficient.

Proportions of blast pipes, wind belt, and tuyere areas are perhaps the most important points, and each maker has his own particular fancy and claims the best results. In designing a cupola for my own use, after having studied the leading makes of British and American manufacturers with the results got from practical experience, I came to the conclusion that there was still room for improvement. Previous to designing an idea of the capacity should be got, and in my particular case I had to provide for a business which was just beginning and was expected to get very large in a short time. Under such circumstances, it is well to make the shell large enough for the maximum capacity required, and line up with extra brick to reduce the inside diameter for present requirements. The size inside shell was made 78 in., this being reduced with an 18 in. lining all round, and with the joints of brickwork the finished diameter was 39 in. inside.

The thickness of plate need not be more than $\frac{1}{4}$ in. for shell and $\frac{5}{16}$ in. for air belt, the latter to be properly caulked at all joints so as to be quite airtight. If all be painted occasionally outside it will last for any length of time. The wind belt should be at least 40 per cent. larger in sectional area than the combined tuyere area. The reason for this difference is that with a large air belt any fluctuation of blast pressure or supply does not affect the blast inside the tuyeres, it being kept constant by the governing effect of the storage inside air belt. For the same reasons the blast pipe connecting blowers or fan should be sufficiently large. In this instance it was made 40 per cent. greater in area than the outlet of blower, the

joint between the two being made by introducing a plate which extended the flange on blower to catch the increased diameter of pipe. In fitting the pipe to air belt it is best to set it at a tangent, so that the blast meets with no direct obstruction on entering. Bends or angles should be avoided as much as possible, but where absolutely necessary they should be open and of large radius. The relief valve should be placed in such a position that the attendant can readily see it.

It is difficult to say exactly what proportion the tuyere areas should be to blower outlet, etc., but I found in this instance that the following particulars gave very good results. There were two rows of tuyeres, the lower row being depended on for doing the work, while the upper row was added with the object of experimenting, and to find out if there was really anything in the theorists' idea of the benefits got from introducing air at a higher level to ignite the gases escaping from the burning coke below. After many trials I do not think it at all necessary for economical melting to have this second row. The bottom tuyeres were much the larger, and were about 18 per cent. greater in total area than the blower outlet. They were shaped almost a square at entrance, but flattened towards the outlet, so that they presented a shallow and wide opening to the inside of cupola. The outlet should be much larger than the entrance, as there is always a diminution of area owing to the coke lying against it. In this instance I made it 100 per cent. greater. The flat horizontal shape is, I believe, the best for good steady melting, distribution of blast and keeping the melting zone within good working limits. It is usual for the centre line of tuyere to pass through the centre of cupola. This throws the blast too much to the centre where the separate streams meet and is inclined to chill. In a cupola with tuyeres arranged in this way I have known a large piece of iron placed in the centre of charge come down through without melting, but a similar piece placed at the side melted all right. To get better distribution of blast I set the one side of tuyere parallel with a line passing through centre of cupola and centre of tuyere entrance; the other side being given an angle which gave the width necessary for the former mentioned proportion. There were four tuyeres in bottom row and eight in the upper row.

The combined areas of the latter was only 15 per cent. greater than one of the former. They were given a good sharp angle downwards to direct the blast in that direction and help to prevent any deepening of the melting zone. The larger tuyeres were 14 in. above the sand bottom, the smaller being 24 in. Shutters were fitted on each tuyere so that the blast could be cut off from any one during a heat. Those on the lower row were made in halves, and opened from the centre outwards, so that the blast had always a fair entrance.

The charging door was placed about 14 ft. above the lower tuyeres. Anything higher in ordinary sized cupolas is quite unnecessary; and to be much lower you lose the benefit got from the heat of the escaping gases passing through the charge. For large heats the sill of charging door should be placed on a level with the platform to facilitate charging direct from trucks or barrows. The stack may be formed by extending the shell to the full height, or by building it of brick, with iron hoops and bands outside to bind it together. It is a good plan to make the stack a good bit larger in diameter than the body of cupola, as the sudden widening lessens the force of the escaping gases, and allows the sparks and dirt to fall back inside, instead of being projected on to the roofs of adjoining buildings. This, however, is not so satisfactory an arrangement as a spark arrester, which shuts in the mouth of stack and directs the gases to the side and downwards, thereby dropping the dirt on to the platform.

The continual nuisance created by cupola dirt collecting in gutters and conductor pipes, with the attention necessary, is a source of expense, and even with all care a flood often happens when you least expect it. The fine particles of iron have a very injurious effect on corrugated iron roofs, gutters, pipes, etc., they being oxidised with the weather and are difficult to remove as they stick hard.

It was against much friendly advice that I decided to adopt the drop bottom. The kind prophets declared its ultimate failure and alteration to the solid bottom, but I persisted, and wonder now what keeps those others from adopting such an easy, cleanly, and otherwise satisfactory method. I have had no trouble whatever with the arrangement, and am not surprised that it is now being adopted in most new plants. There are about twenty foundries in this district all within a radius of three miles, and many have two or more cupolas, but

at this time there were only two with drop bottoms. It was tried quite recently at one of those and abandoned as unsatisfactory, but I am afraid the foreman there did not know any more than the cupola tender.

In regard to the lining, I firmly believe that it should be straight from bottom to charging door. Any reduction of diameter at tuyeres only tends to cause bridging by disarranging the charges as they come down. It is only in very large cupolas that any reduction is necessary to allow of the blast penetrating to the centre.

In selecting a suitable brick, care should be taken to get the best make of firebrick, as it pays better in the long run. The quality should be so good that it will last one year, having a daily cast of from 15 to 20 tons, *i.e.*, with proper attention. It is of little importance whether large faced brick, such as Americans use, are adopted, or the ordinary 9 in. by 4½ in. by 3 in., provided the quality of the grouting is equal to the brick used. Very little grouting is allowable, as the more solid the building is the better. A good plan is to mix up the ground fireclay with water to the consistency of treacle, and dip the bricks into it; quite as much will adhere as make the joint, and after tapping into place with a hammer a close job will result. Between the shell and outer ends of brick it is well to make a fairly wide joint of ¾ in. to 1 in., which should be filled in with coke dross or moulding sand, to allow of free expansion and contraction. Around the tuyeres a solid joint should be made with asbestos packing to prevent any escape of air between the lining and shell.

It should be borne in mind that volume and not pressure is the more important factor in serving blast to a cupola. I know of 1 lb., 1½ lbs., and even 2 lbs. pressure being used, but when you look at the size of tuyeres, the reason for such high pressure is explained. It is difficult to get the necessary volume even with those pressures through such small openings. High pressure only tears up the coke, burns out the lining and chills the face of tuyere without adding anything to the economy of melting. The molten iron is degenerated through oxidation, by being exposed to the cutting blast; besides, the blowers or fans are run at such high speeds that there is great tear and wear. In some places they drive the blower so hard that it is a matter of expense and difficulty keeping the engine in repairs. In such cases the arrangement of having an engine direct coupled to blower is often condemned. I had a No. 5 Roots blower with direct-coupled engine in the arrangement described above, and can confidently recommend it as being a very satisfactory machine. It gave no trouble whatever, and when running was just allowed speed enough to lift the valve, which was set at ¾ lb. I appreciated the comfort and convenience of not being annoyed with belts, and their accompanying troubles. The noise of the gearing in blowers may be greatly done away with by adopting a chain drive between the two revolvers. I have no experience with fans for melting iron. According to results of tests made in America they are not so good as blowers, but there is so little difference I should not hesitate to use them.

The more pieces the pig-iron is broken into the quicker it melts, and the better it is mixed; but time is considered of such importance by manufacturers that few founders break the pig in more than four, and the majority in only three pieces. The breaking in three can be done entirely when disloading from the railway trucks, by simply allowing the pig to drop on to a block of iron with two V-shaped ridges distant apart one-third of the length of pig. The approved way to charge pig-iron is to place the pieces radially with centre of cupola, one end close against the lining, the clean broken ends being towards the centre, so that they melt readily when exposed to the incandescent coke. The idea to aim at is to have a core of coke up the centre, with the pieces of pig packed close around it. This practice requires more time and attention than is generally allowed, and is principally beneficial in very small cupolas; or during the first charge or two. It therefore is common practice to handle the stock by trucks or other similar means and charge direct from these. It is good practice to put the complete charge in trucks and have these stored on cupola platform previous to charging. The stock yard should be alongside the railway track, and convenient to the cupola, preferably on the same level as platform; but if not a hoist wrought by steam or other quick means should be provided.

There ought to be sufficient plant in the way of ladles, etc., to keep the tapping hole always open, as this is the only proper way to get iron from a cupola having the composition of the charge. Iron kept or collected in the cupola steadily cools and deteriorates through the action of the blast and the slag floating over it. Where several brands of

pig are used, and it is important that the castings should have a particular analysis, a mixing ladle should be provided. A good arrangement is to mount a self-skimming ladle on trestles in such a way that it is always in a position to receive the stream from the spout, whether in the pouring position or upright. It should be fitted with worm gearing for canting, and the capacity should be about 50 per cent. more than the distributing ladles to allow for changing. In cases where the iron is taken away from the cupolas by means of truck or trolley ladles, and no particular mixing is required, the spout can be arranged with a T-piece. This T-piece is hung in the centre, and is controlled by gearing or other suitable means so that it can be canted, thus diverging the stream of molten iron to either side. Enough ladles must be provided to ensure an empty one always being in position at the other end of spout, before the one being filled is up. An arrangement like this works very successfully in stove and grate or light pipe shops, where they do not require a mixer.

The results got from the cupola described in this article were very good, and the following is a copy of our everyday practice:—

Coke bed charge, 10 cwts.
First iron charge, 25 cwts.
First coke charge, 2½ cwts.
Second iron charge, 25 cwts.
Second coke charge, 2½ cwts.
Third iron charge, 25 cwts.

and so on.

Time blast on, 3-0.
Time iron down, 3-5½.
Time first tap, 10 cwts., 3-9.
Time second tap, 10 cwts., 3-12.

and so on, melting at the rate of 6½ to 7 tons per hour.

When special care was taken we melted 25 cwts. of iron with 2¼ cwts. coke, exclusive of bed charge.

——o——

The engineering businesses of Mr. P. Hamilton, 53, Victoria Street, Westminster, London, S.W., and Mr. N. Hamilton, 19, Waterloo Street, Glasgow, have been amalgamated under the style of Messrs. Hamilton Brothers.

The engineering works at Gainsborough of Horn, Littlewood & Company, Limited, formerly known as the Aegir Works, were recently offered for sale by public auction. Only one bid of £1,000 was forthcoming, and the lot was withdrawn.

THE NEW FOUNDRIES OF THE HOLWELL IRON COMPANY, LIMITED.—II.

General Foundry.

This building is also 120 ft. long, and is composed of two bays, each 45 ft. wide, divided by a heavy brick wall with arched openings. The foundry is principally used for large special pipes. One of the bays is designed for loam work, and is provided with a 30-ton three-motor overhead electric crane. The other bay is provided with a 7-ton crane. One foreman looks after both the general and the plate foundry, his office being in the general foundry, and elevated so as to command a complete view. The special feature of this foundry are the stoves, which are below the floor level. The old-fashioned core carriages are dispensed with, the moulds being lifted by the 30-ton crane and dropped into the stove. It is claimed that by this system the mould is less likely to be damaged than when it is placed on a core carriage and pushed into the oven. The moulds are all dried by producer gas. The foundry is provided with a loam pit for cylinders, hydraulic rams, and, indeed, for all classes of work that are cast vertically. This pit is bricked throughout, and is 24 ft. deep. For the first 12 ft. it is 16 ft. in diameter, the lower 12 ft. being 12 ft. in diameter.

The core oven is lined with a projection on which a number of girders rest. These girders can be moved into any position to suit. The gas is led in by a pipe, there being one pipe to each pit. The burnt gas is drawn off by an exhauster attached to the flues. The bottom of the stove is a series of pipes which lead the gas to the exhaust flue. The oven is covered with flat iron plates stiffened with angle pieces and filled in with sand. This cover, which is in three parts, is lifted off by the crane. All the spindle and loam work is dealt with in the same core oven.

The machinery in the foundry, including loam mill, is electrically driven. One feature of the foundry is that it is exceedingly light. The same system of glazing is used as that for the machine shop, and all the walls are whitewashed every four or five months.

Pipe Foundry No. 1. (Fig. 12.)

This is the main feature of the new works, and is known as Section E. The foundry is 220 ft. long by 100 ft. span,

and has four circular pipe pits for casting pipe in 12 ft. lengths. The whole of the pipes are moulded and cast vertically in dried sand moulds, socket end downwards. The pits are 30 ft. in diameter, and 14 ft. 6 in. deep. Each pit has a circular flue underneath the pipe flasks or boxes, which supplies producer gas for drying the moulds in position in the pit. Each pit is also provided with a sand conveyor. The floor is provided with grids, on which the sand falls through to a conveyor. It is elevated and dropped into wagons outside the foundry and taken to the sand mixing mills, re-ground, and tempered ready for further use. Every pit is connected with its neighbour by an underground tunnel, so as to allow a man to go from one pit to another. Each pit is designed to turn out about 600 diametrical inches per day of single shift, which means fifty 12 in. diameter, or thirty 20 in. diameter, etc., etc., pipes per day, sizes up to 36 in. diameter being cast.

FIG. 10.—GENERAL FOUNDRY (SECTION C); HOLWELL IRON CO., LTD.

Many features of interest are comprised in the electric radial cranes which are in use over each pit. The designing of pipe foundry cranes to meet the many requirements such as reliability, high speeds, easy manipulation, the minimum of wearing parts (and these parts dust and damp proof), easy access to all details, and a motive power that can be depended upon through all variations of climate, is not quite so easy a problem as it appears. When it is considered that the modern pipe foundry is nothing short of an automatic machine, and the principal factor in this machine is the cranes, the importance of the design becomes at once apparent. Many engineers have devoted much time to the design of pipe foundry equipment, and have met with varied successes. Those who have obtained the greatest success are those who have had as their object, a perfect cycle of operations. The principal operations taking place in a foundry may be put down as core-making, ramming, finishing, setting cores and casting, stripping, and dealing quickly with large quantities of hot sand. It must be readily seen that the highest point of efficiency can only be reached, when the equipment of machinery and men is so arranged, that a continuous cycle of these operations is possible, and the maximum tonnage produced from the minimum amount of tackle.

The cranes are of somewhat novel construction—and may be called electric twin radial cranes, supported entirely from the roof, and without a single pair of spur wheels being used for any motion. The centre post on which both cranes rotate independently, in any direction—and being radial it is obvious the length of travel is infinite—carries two sets of ball bearings, on which the cranes rotate. An electric motor is provided for each motion—hoisting, revolving or travelling, and racking. Each motor is coupled direct to a specially designed worm gearing, enclosed in a dust-proof case; the worm runs in an oil bath, and the thrust is taken up by ball bearings. The hoisting and racking motors are fixed at the end of each crane near the centre

post; by this means the crab is reduced to a simple trolley without any gearing of any description, and the motor for revolving is coupled direct by means of similar worm gearing to the wheels on the circular track, this track being 46 ft. in diameter. The cranes are designed to lift a load of 8 tons at 40 ft. per minute, the motors being series wound—lighter loads may be lifted at proportionately increased speeds—to revolve at 250 ft. per minute, and to rack or transverse travel at 50 ft. per minute, each motor having a guaranteed overload capacity of 50 per cent. for two hours; both automatic electric and mechanical brakes are provided. One of the most gratifying results of the design of these cranes is the total absence of noise. If the hook blocks are not actually seen in motion, there is no other indication of their being operated. One of the advantages in having these cranes entirely supported by the roof, is that the pit is free from any obstruction, and the men can work with at least as much comfort as on the foundry floor, and another advantage is that the floor of the pit can be made into a grating through which the hot sand falls into a conveyor and is immediately carried away outside the foundry to the sand mixing and tempering sheds, as already described. The cranes, as well as the other engineering work at the works, were designed by Mr. T. V. Miles, the engineer and foundry manager of the Holwell Company.

The arrangement of the building is a central bay, in which the pipe pits are located and a lean-to addition which contains 20 core ovens for the pipe cores. These ovens are 16 ft. long by 6 ft. by 8 ft. The ovens are gas heated. At one side of the foundry, close to the core ovens, is the core-making department, where a mixture of horse manure, loam, and sand is splashed on to iron core bars.

For dealing with the core-making, two sets of electric walking jib cranes are used to each pipe pit, one crane for core-making only, and the other for transferring the finished cores to the radial cranes, and returning the core bars to the core-makers. These cranes run on a single rail on the floor, and the top is supported by a channel. It will thus be seen that the design provides for two walking cranes for the core ovens and two radial cranes for moulding, ramming, and casting for each pit. At present pipe from 3 to 36 in. diameter is being cast, but it is the intention shortly to cast pipe up to 72 in. diameter.

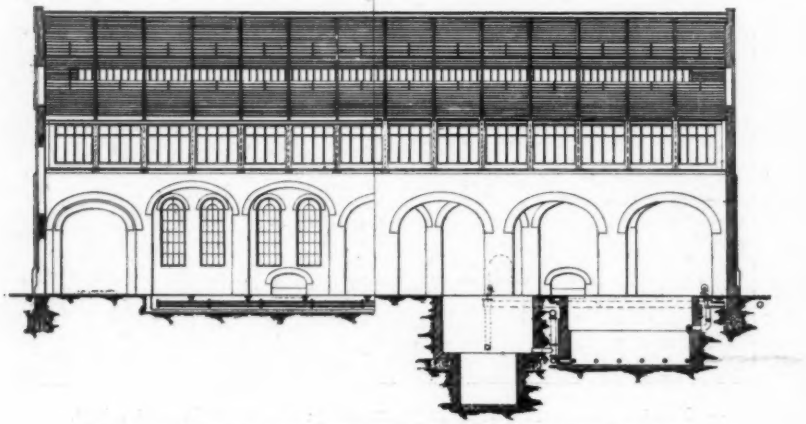

FIG. 11.—GENERAL FOUNDRY (SECTION); HOLWELL IRON CO., LTD.

Pipe Foundry No. 2. (Fig. 13.)

Beyond the main pipe foundry is Section G, which is the last addition, and is a foundry for small sizes of pipe up to 5 in. in diameter. The building is of brick, and is 200 ft. long by 60 ft. span. The pipe pit in this case is arranged on the rectangular system, and the cores are set and the pipes drawn four at a time. Precisely the same type of flask is used as in the larger foundry, and all pipes are cast socket down with a head of metal on the spigot end, which is afterwards cut off in a lathe. Each pipe pit is

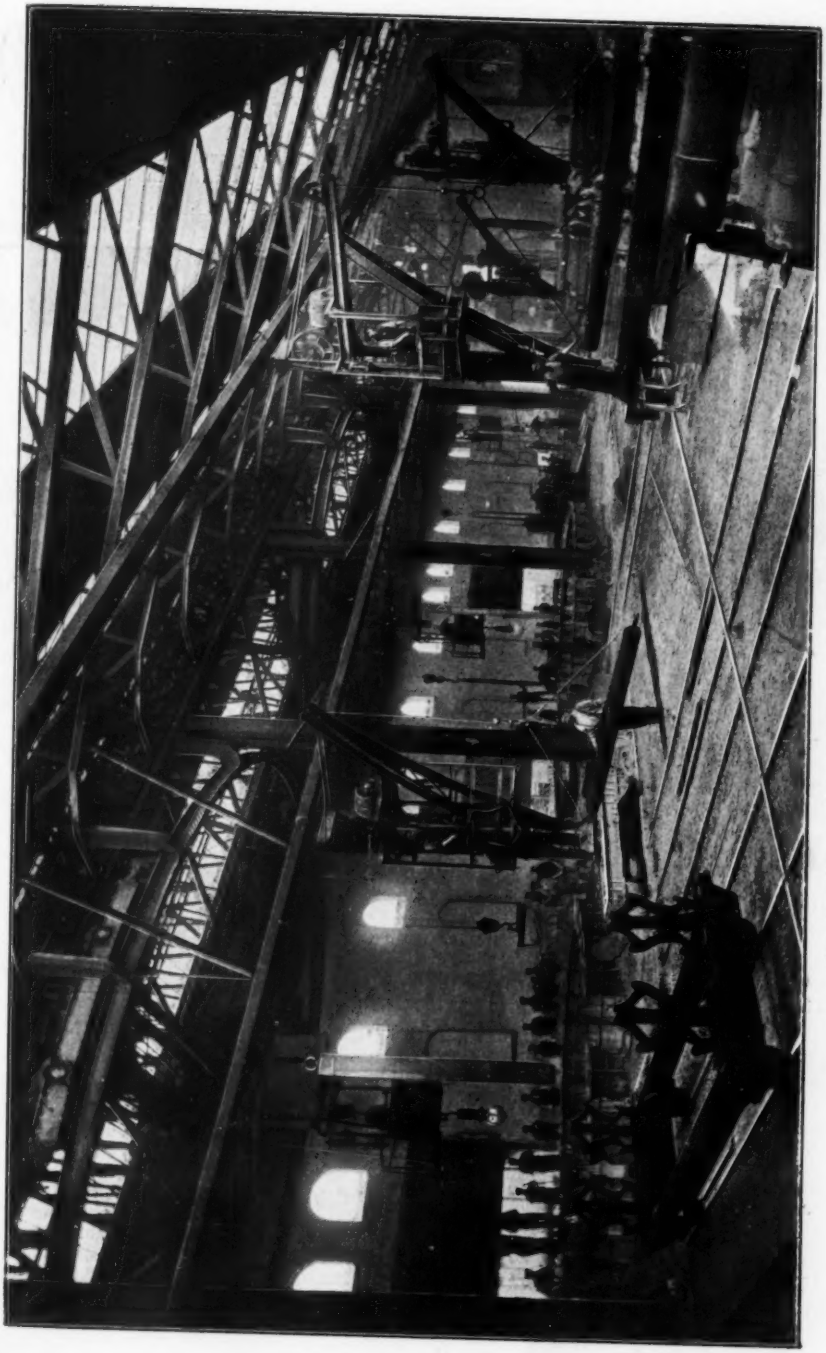

FIG. 12.—LARGE PIPE FOUNDRY; HOLWELL IRON CO., LTD.

spanned by a 5-ton 3-motor electric crane by Booth Bros., of Rodley, specially designed and working very noiselessly. Along one side of the building are the core ovens. There are nine of these, each sufficiently large to hold 100 cores. The ovens are all heated by producer gas. The gas is conveyed to the core ovens by means of a brick flue, and is burned in a combustion chamber in the core oven. In the pits, the gas is conveyed in a similar manner, and sheet-iron cones or burner pipes convey the gas from the flues to the centre of each pipe mould. In between the two pipe foundries are two Thwaites cupolas with a melting capacity of 8 tons per hour each. These supply the pipe foundry in addition to the large central cupolas described above.

FIG. 13.—No. 2 PIPE FOUNDRY (SECTION G); HOLWELL IRON CO., LTD.

Fettling and Cutting.

The pipes after being cast are stripped and rolled on to a fettling gantry, which runs at right angles to the two pipe foundries. After fettling, the pipes are rolled to the cutting-off shop. This is a long building running parallel with the two pipe foundries, and contains a number of cutting-off machines. These machines handle pipes up to 36 in. in diameter, and are fitted with a specially designed tool holder.

The finishing of the pipes is so arranged that they run by gravity from the foundry to the shipping yard. From the cutting-off shop the pipes roll on gantries to the testing department, where the water pressure test is applied. This section of the plant is covered by a light galvanised roof with skylights. There are six proving presses supplied with hydraulic pressure by an electrically-driven pump and accumulator. Each press is provided with two lines of pipes, one for oil and

one for water. Adjoining is a centrifugal pump house, which contains Gwynnes' pumps for lifting the water to the tanks for testing and for pumping the oil. One of the presses takes pipes up to 48 in. diameter. The other is for smaller sizes. After testing, the pipes are rolled to the heating stoves and thence to the dipping tanks, where they are coated with rust-preventing composition known as Dr. Angus Smith's solution. It may be observed that from leaving the foundry to this point the conveyance of the pipes has been accomplished by gravity. They are taken out of the dipping tanks by a steam crane and laid on skids to be weighed and shipped. Particular attention is paid to the coating in order to secure a first-class result, and the plant for this purpose is most complete; the stoves are heated by producer gas. The siding accommodation—which belongs to the Company—is ample, and is connected with the Midland Railway. The sidings are arranged on a gradient of 1 in 78 fall to the 40-ton Pooley weighing machine; ample room for the inspection of the pipes is provided, and there are three rows of sheds for testing. There are also large storage gantries and stock yards adjoining. The proving presses and stock gantries are shown in Figs. 14 and 15.

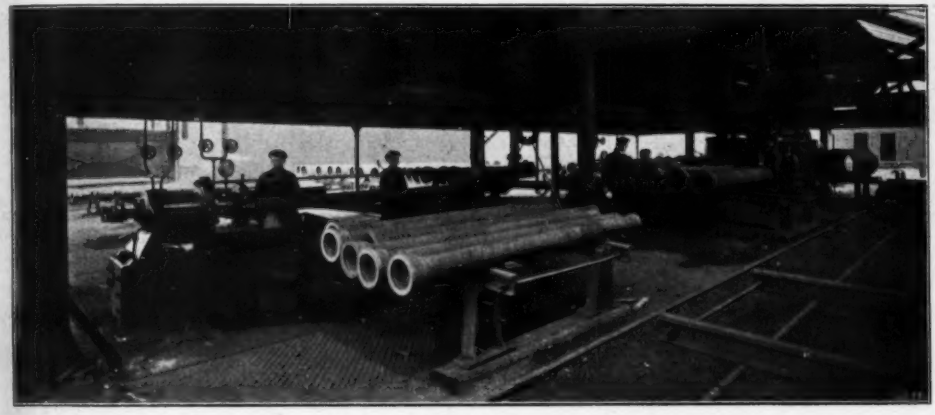

FIG. 14.—HYDRAULIC PROVING PRESSES; OLWELL IRON CO., LTD.

Pattern Shop. (Fig. 16.)

This is a spacious building, with the American mill type of roof and glass sides. It is shown in Fig. 16. Its dimensions are 120 ft. long by 45 ft. wide, and in size it is an exact duplicate of the Section B plate foundry already described. The building is heated by hot water pipes, and all the machines are electrically driven. The equipment does not call for special notice. It embraces Fox trimmers, a Robinson planing and thicknessing machine, circular saws, and other wood-working tools.

The producer plant consists of three 8-cwt. Duff & Whitfield producers. These producers generate gas from a mixture of cheap bituminous slack and cheap cannel coal; the mixture being about 50 per cent. of each.

The ground was first cut for the new works five years ago last March; within eighteen months the Company was taking orders, and in twelve months the machine shop and general foundry was complete. Fourteen months later the pipe foundry was completed, with a capacity of 500 to 700 tons a week.

Before the building was commenced Mr. T. V. Miles, the engineer and foundry manager, paid a visit to the best works in America and the Continent of Europe. On his return he designed and laid out the whole of the plant and equipment. The foundry is probably the most modern in the country.

The Electrical Equipment. (Fig. 17.)

The electrical installation is on the continuous current three-wire system, current being generated on 475 volts across the outers, the larger motors being taken off the outer mains and the smaller motors and lights taken off the middle and outers.

The new station is about 700 yards from the foundries, and situated at the blast furnaces, where advantage can be taken of the waste gases to generate the steam required. The greater portion of the electrical equipment in the old works is for 460 volts supply.

It was therefore arranged to run the 475-volt mains from the generating station to the foundries, the size of the conductors being so designed that the losses in them reduced the pressure from 475 to about 440 volts. These mains are of bare stranded copper, carried overhead, six pairs of them being provided between the foundries and the generating station. Two sets of rotary balancers were provided at the foundries for the three-wire system, one being used for the lights and the other for the power.

panels. A separate panel is provided for each of the generators and the requisite number of panels for the various distribution circuits. The busbar voltmeters are mounted together on a swing panel at one end of the board.

The board is erected on a platform slightly raised above the engine room floor, and the busbars, which are of bare copper carried on insulators, are run behind the switchboard at the power station, and underneath in a large cellar accommodation in the sub-station, the various circuits being directly connected up to these busbars through the feeder switches and fuses.

There is a considerable amount of space left in the engine room for additional plant should this ultimately become necessary.

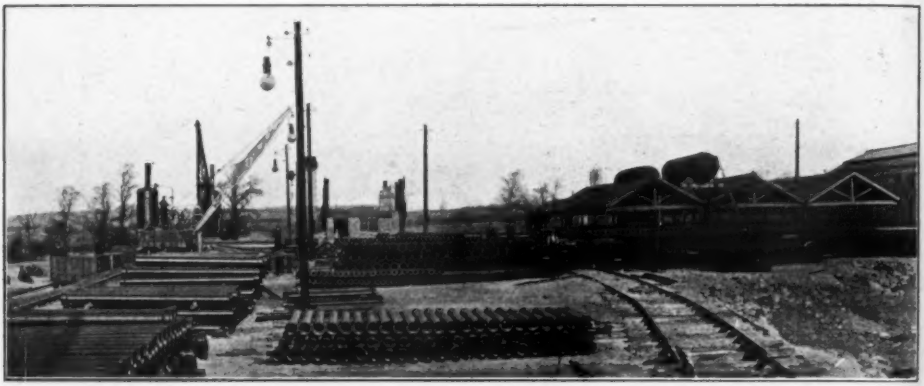

FIG. 15.—STOCK GANTRIES—SMALL PIPES; HOLWELL IRON CO., LTD.

At the present time the generating station consists of two 150 kw. compound generators direct-coupled to Messrs. Belliss & Morcom's vertical enclosed type engines, and a 275 kw. compound generator direct-coupled to one of Messrs. Willans & Robinson's central valve engines. The three generators are fitted with a patent slip-ring attachment, which, working in connection with a static balancer, controls the voltage for the three-wire system for a number of the motors and lights at the furnaces. The machines themselves are of the most up-to-date multipolar type, fitted with carbon brushes having a fixed position with all loads.

The switchboard, which, for a private installation, is an extremely handsome one, consists of polished white marble

The whole of the feeder system consists of bare stranded copper conductors carried on insulators, the insulators being supported by steel trellis poles and iron brackets on the buildings. Provision has been made on these poles for room for six additional circuits should they afterwards be required.

With regard to the motors, the Holwell Iron Company have very wisely gone in, as far as practicable, for individual drive, so securing the highest possible working economy.

The actual number of motors installed is too large to permit them being referred to individually, but the aggregate output of all the motors is in the neighbourhood of 1,100 b.h.p.

Among the largest of those installed are two compound-wound motors for

driving, by belt, slag crushers, one having a normal output of 120 b.h.p. at 440 r.p.m., the other 78 b.h.p. at 540 r.p.m. There is also a 100 b.h.p. motor coupled to one of Messrs. Gwynnes' centrifugal pumps, this pump supplying water to the new works from a reservoir of a capacity of 14,000,000 gallons, in the valley. There are also two 47 b.h.p. motors running at 600 r.p.m. each, one driving a cupola blower.

The lighting consists of mixed arcs and incandescents, between 95 and 100—10 amp. open type arc lamps being in use, capable of burning four in series for 32 hours off a 220/230 volt main.

The cupola blowers at Section G are driven by 30-h.p. motors at 900 revolutions. The cupolas at Section C_2 are driven by 10-h.p. motors, also at 900 revolutions. The loam mills are driven by a 50-h.p. motor at 600 revolutions, and the series of special lathes for cutting off the pipes by a 50-h.p. motor at 600 revolutions. There is also a similar motor for driving the air compressor for the smiths' hammers and pneumatic tools. All stationary motors of 10-h.p. and upwards are run direct from the outer mains, at 440/460 volts.

FIG. 16.—PATTERN SHOP; HOLWELL IRON CO., LTD.

PRINCIPLES AND PRACTICE OF FOUNDRY WORK.

AT a meeting of the Cleveland Institution of Engineers recently held at Middlesbrough,

MR. ROBERT BUCHANAN, of Walsall, read a lengthy paper (of which the following is an abstract) on "Principles and Practice of Foundry Work." He said that two main ideas were held regarding foundry work—one that it was so simple and grimy as not to be worth serious study, the other that it was so complex and so subject to causations unexplained and unexplainable as to make the study a hopeless task if one sought for definite conclusions and definite results. But there was a middle field of ascertained fact helpful to the foundryman, and beyond that was a region of probability. Referring to cupola practice, it was stated that any modifications which the foundry cupola had undergone of late years were in the direction of increased rapidity of melting with a lower consumption of coke. That had been obtained by increasing the number of

tuyeres. In British practice double and triple rows of circular tuyeres were in common use. In America the sheet tuyere—a long narrow slit, sometimes extending wholly round the cupola—was often used. Flat or sheet tuyeres might allow a shallower bed of coke to be used, but flat tuyeres more readily tended to the hanging of the charge than round tuyeres did. Various shapes of tuyeres—triangular, tee shaped, etc.—had been tried, but no advantage followed their use. Circular tuyeres really caused less trouble than any others, but they should not extend too high. As a opinion that the parts of the cupola which were not contributing their due share of the melting were those areas near the circumference and lying between the tuyeres.

Economies had been effected in the cost of melting largely by heightening the cupolas, when combustion was more thorough. Some foundrymen reduced the diameter of the cupola in the region of the tuyeres, but that was not a universal custom. It saved coke and distributed the blast well, but was not an unmixed blessing. Cupolas so drawn in more readily "hung up," or "scaffolded,"

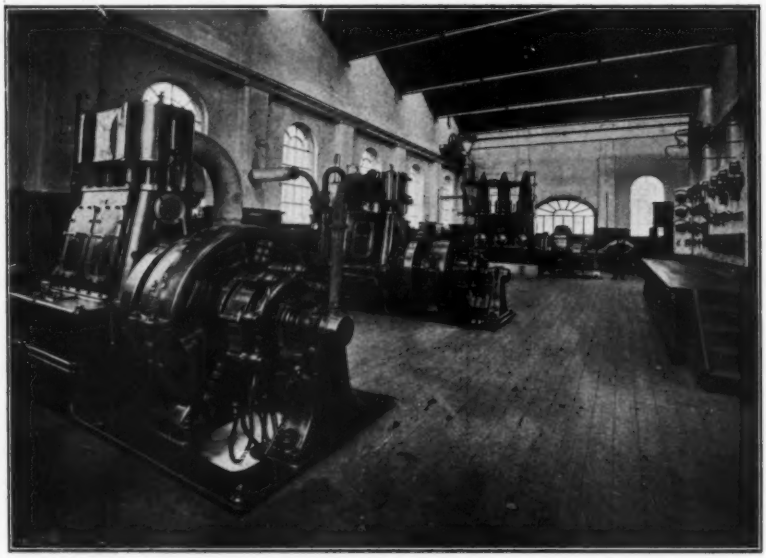

FIG. 17.—ELECTRIC POWER STATION; HOLWELL IRON CO., LTD.

rule, tuyere area was too restricted, and ideas were changing as to whether the air supply should be at high pressure or low. After all the volume of air was the important thing, and some foundrymen were reverting to the fan for their air supply with satisfactory results. It might be objected to low pressures, that with a cupola of large diameter the air would have difficulty in reaching the centre of the cupola, but that was not the case, and the author gave his reasons for his opinion. There was, however, a steady decline in quantity of iron melted per foot of superficial area with each increase of diameter of cupola. He was of and there was the weekly building up of brickwork, or ramming of ganister round a plug.

Some valuable information was given by the author with regard to the relative values of beehive and by-product cokes. The coke from by-product ovens was black, and even unsightly in appearance, but in no other respect was it inferior to beehive oven coke. He had used thousands of tons of each. The "black coke," as the cupola men called it, was of an irregular structure, and did not break down into small pieces so readily as the beehive oven coke. The ash in coke for foundry purposes should

not exceed 8 per cent., and if the coke contained less than 88 per cent. of carbon it should not be received at the foundry. Such cokes were always high in ash, and thus had deficient melting power, and required extra limestone to flux the ash. A low percentage of sulphur was absolutely necessary. No foundry coke should have sulphur over 0.80 per cent. Wet coke melted iron as economically as dry coke.

In respect to pressure of blast, the best results would be obtained with it ranging between 12 and 16 ozs., when the cupolas were 36 to 54 in. diameter inside. The volume of air required to melt one ton of iron was usually between 38,000 and 40,000 cubic feet. The pressure and volume of blast had a great influence on the hardness or softness of castings. Rapid melting with a low consumption of coke might be purchased too dearly by depreciation of quality, loss of iron, and loss of the constituents which made the iron valuable to the foundryman.

Discussion.

The discussion arising on the paper was lengthy and animated.

Mr. Joseph H. Harrison, the President, stated that the paper was a very excellent one, and brimmed over with information which could be put to useful purposes by founders.

Mr. Peter Munnoch, Anderson Foundry, Port Clarence, called attention to the importance of the statement made respecting the grading of pig-iron, that it was based upon the appearance of the fracture, and the appearance of the fracture was mostly governed by the length of time the pig-iron took to cool, which showed how inadequate and misleading was the judging of quality by appearance of the broken pig. Also it was stated that an open-grained fracture and a high percentage of sulphur were not readily found in the same iron. Founders in this country did mostly get iron which was judged by fracture only, and as Mr. Buchanan said, the composition of the iron really varied very much from time to time. Perhaps those interested in blast furnaces would give their idea of the subject. Would they say whether pig-iron could be graded by anything but fracture?

Mr. Adamson, of Seaton Carew, remarked that they recognised in Mr. Buchanan an out-and-out opponent of grading by fracture. He was very near the truth when he said that the appear- of the fracture was governed by the length of time the iron took to cool.

Mr. Ridsdale, North-Eastern Steel Works, Middlesbrough, also considered that the character of the fracture of pig-iron was a question of temperature—the rate of cooling.

Mr. Robert Anderson (Head, Wrightson & Company), Teesdale Iron Works, Thornaby-on-Tees, drew attention to the assertion that it was possible to use too little coke for melting the iron. Would the author say what he considered too little? In the North-East of England, where they had to pay 24s. or 25s. per ton for coke, every ounce saved was of importance, and they would like to know exactly what quantity to use. Blast furnace owners were much to blame for the great variations in the pig-iron they supplied. It was one of the greatest difficulties in the world for a foundry manager to get an even quality of pig-iron, even if it were guaranteed.

Mr. H. Stonewall Jackson (Richardsons, Westgarth & Company), Middlesbrough, said they, as founders, ordered, and expected to get, one grade of pig-iron, but as a matter of fact often five or six were sent. If the foundryman could get what he ordered he would be saved many difficulties. Pressure and volume of the blast accounted partly for the variations in the hardness or softness of the castings, and he had had to condemn more than one casting because the degree of hardness was not what he wanted. Mr. Buchanan had pointed out good reasons for the variations in the quality of castings.

Mr. J. E. Stead, F.R.S., Middlesbrough, said Mr. Buchanan had found that the application of very careful chemical methods at his foundry had saved him money.

Mr. F. Herbert Marshall, Tees Iron Works, Middlesbrough, said the writer of the paper was a scientific foundryman, and wanted all the foundrymen to become scientific likewise. The ordinary foundryman, however, liked to test a thing by aid of the hammer. He should buy his pig-iron by analysis, and if he wanted it in that way instead of by fracture he could get it, just as consumers bought hematite iron by analysis. Cleveland iron was not sold by analysis because no one asked for it, but it or any other iron could be supplied on that understanding. The foundryman, as a rule, was utterly careless of his materials, and if anything went wrong he at once blamed the pig-iron.

Mr. H. G. Scott, Ormesby Iron Works, Middlesbrough, held that to carry out Mr. Buchanan's recommendations would

mean the holding of large stocks of pig-iron and the obtaining of regular analyses. The blast furnace owner sold by fracture because the founder insisted on buying it thus.

The PRESIDENT intimated that Mr. Buchanan would reply in print to the criticisms made in the discussion, as time did not permit of a detailed reply by word of mouth that evening.

COST KEEPING.

"METHODS of Keeping Foundry Costs" was discussed at a recent meeting of the Pittsburg Foundrymen's Association.

MR. W. A. BOLE, General Manager of the Westinghouse Machine Company, East Pittsburg, Pa., briefly discussed the method of cost keeping in the foundry operated by his company. He said that experience in the building of engines proves conclusively that many builders of these machines do not know their cost of manufacture. The phenomenally low bids often offered showed this, and several of these manufacturers remained in business only as long as their capital held out. In purchasing material he stated that he has had the same experience, one concern underbidding another as much as 50 per cent. on certain classes of work, while on other jobs the reverse would be true. He concluded that these manufacturers likewise had loose systems of computing their costs.

Mr. Bole then presented a table which clearly indicated the method of splitting up the foundry pay-roll, and which showed the relative cost per cent. of the various classes of wage labour. This covered the 12 months of 1906, and is exceedingly valuable for its detailed information. The table follows:—

	Per cent.
Wages of moulders	35.7
Wages of helpers	7.4
Coremaking	12.8
Melting, including all the labour engaged at the cupola and in the yard	3.2
Day and night labour...	6.9
Chippers and cleaning castings	7.0
Miscellaneous labour	3.6
Shipping	1.5
Wages of men employed in the light and power departments	2.0
Wages of men engaged in renewals and repairs to power plant	0.3
Wages for repairs and renewals to foundry flasks	3.3
Wages for repairs and renewals to cranes ...	0.6
Wages of foundry foremen and clerks ...	6.7
Wages of blacksmith and helper for bar iron work and work on chaplets, etc.	0.4
Wages of labourers	0.3
Wages of superintendent and clerks	4.0
Electric crane operators	3.7
Lavatory attendants and yard labour	0.6
Total	100.00

THE MOULDING OF A HALF-POLE SHELL FOR AN ELECTRICAL GENERATOR.

BY W. THOMPSON.

PREVIOUS to commencing work upon this particular job, a knowledge of the finished casting (a sketch of which is given in Fig. 1) would, of course, prove beneficial to the moulder, who finds himself in possession of a strickle, two half-feet of opposite hands (Figs. 2 and 3), and other small facings. First of all, the tackle which is required is commenced upon, and proceed by making the bottom plate (one half shown in Fig. 4), and as it is required to stove this job, it is made in halves for the purpose of better handling and stove room. Owing to the depth of the foot, holes are cast in the plate and pockets (see Fig. 5) bolted on as shown. The top plates correspond with the bottom ones, except that holes are cast in for the purpose of feeding the job after pouring, and that two extra handles (shown by dotted lines, Fig. 4), which are required during turning the tops over, are also cast on each top half. The prods are also kept a little shorter to allow of the joint plates (Fig. 6) to be bolted to the tops. Two end plates (Fig. 7) are next made, one being cast with a hole through for the runner gate. This completes all the tackle required.

The cross and spindle having been set true, a level half-circular bed is struck off roughly with the flat edges of the strickle which has for the nonce been turned upside down, and a straight line marked off by means of the straight-edge (some 20 ft. long), and the centre of the spindle. The circular outline of the plates is also marked off, and the plates placed thereon. The strickle is now reversed, and the half-feet bedded in true to the centre line, which is found by the aid of the straight-edge and the centre of the spindle, taking care that the strickle follows the feet close during the sweep. This is next followed by the brickwork being carried to the requisite height. Fine ashes are now placed over the plate where necessary for carrying off the gases during casting, care being taken to connect them with the outside of the mould. A layer of loam is next spread over the ashes and the brickwork, and the mould vented where required. After carrying a facing of loam ⅛ in. over the centre line of the feet at the ends to allow of machining, and when the final coating of loam has been applied, the feet are withdrawn, bad places made up, a sharp trowel

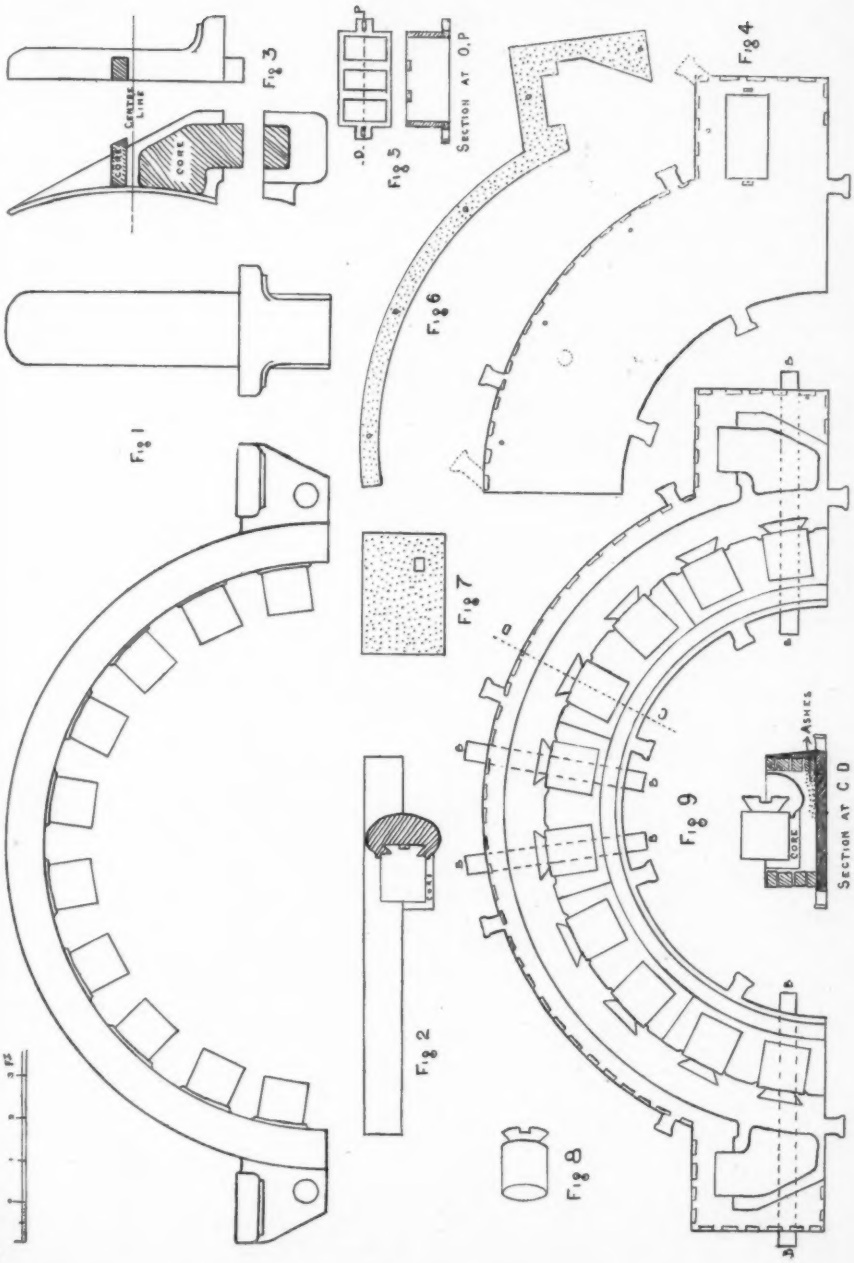
Fig 1
Fig 2
Fig 3
CENTRE LINE
CORE
Fig 4
Fig 5
O.P
SECTION AT O.P
Fig 6
Fig 7
Fig 8
Fig 9
ASHES
CORE
SECTION AT C D

run between the joint of the two plates, and each half of the drag is then ready for drying in the stove.

The top plates are now placed in the position previously occupied by the two bottom half-plates, and the feet bedded in similar to the previous half; next followed by the brickwork being carried to a sufficient height to allow of the joint plates to come on top. These, when bolted to the top plates, carry the brickwork, during and after being turned over. No ashes are placed on the top plates, as none are required, also dispensing with the brickwork at the inside, which only serves as a guide during coring up; finally treating this half in a similar manner to the drag. The two end plates are next struck up with a level face and stoved.

As soon as dried, and whilst warm, all parts exposed to the metal receive their facing of wet blacking or plumbago, drying itself during the process of cooling. A pit is then dug of the required depth, which conforms to the shape of the bottom plates, and the two halves of the drag placed on a level bed which has been struck up and on beams (marked B, Fig. 9) placed so as their tops rest a little below the surface of the bed. Great care has to be exercised during this operation, so as to bring the two halves of the drag into the same relative positions they occupied previous to being parted for stoving. The joint also requires careful attention by making up safe and sound, lest the pressure of metal during casting find a weak spot and burst out, and in all probability result, although all other parts of the mould were sound, in a failure. The two top halves of the mould after having been turned over are now tried on the drag, and when correctly placed, are staked for the purpose of returning to the same positions after coring up. The tops are again lifted off, and upon the receipt of the cores, which have been previously made by the coremakers, the work of coring up is commenced. By getting the middle bottom core in its correct position, the others follow in their proper places. The foot cores then receive attention, and all the ashes which have to carry off the gases during casting are connected with the outside of the mould. The pole pieces (Fig. 8), which are made of steel, are then put in their respective places in the bottom cores, and a plan of the mould previous to the placing on of the pole piece top cores is given in Fig. 9. After putting the top cores on, the top halves of the mould are then lowered towards the drag, the stakes returning them to their correct positions. The end plates are next brought against the ends and all joints carefully loamed up, followed by beams placed across the top to correspond with those which have been previously placed underneath. The mould is now bolted down and cramps applied where there exists a doubt as to being thoroughly secure, followed by the pit being rammed up, during which all passages for gases are carried above the flooring. Runner and risers are made up and with the metal at the correct heat, the pouring passes off nicely, the job fed at the two feet and centre risers, and a sound casting is the ultimate result.

The moulding for the top half casting is carried out in exactly the same method as previously described, except that there is a reversal of each half of the feet when bedding in.

The foregoing article has been made as brief as possible to avoid worrying the reader with unnecessary detail.

—o—

DEATHS.

Mr. T. Smith, for many years the principal of the Caslon Letter Foundry.

Mr. T. Pilling, secretary of the Britannia Foundry Company, Rochdale.

Mr. W. Allen, late representative of Cammell Laird & Company, Limited, Sheffield.

Mr. S. Fearnside, of Messrs. Samuel Fearnside & Sons, Albert Foundry, Keighley, Bradford, aged 70 years.

Mr. Henry Warrington, head of Messrs. Henry Warrington & Son, Berry Hill Iron Works, Stoke-on-Trent, at 68 years of age.

Mr. Thomas Metcalf, general manager for the firm of Messrs. Smith, Patterson & Company, ironfounders, etc., Blaydon, aged 67 years.

Mr. Victor Haslam, eldest son of Sir Alfred Seale Haslam, who held a leading position in the business of the Haslam Engineering Company, of which Sir Alfred is head.

Mr. J. Caird, ironfounder, of Barrow, at the age of 35 years. Mr. Caird was the only son of the late Mr. David Caird, ironfounder, etc., Barrow, and he carried on since his father's death the ironfounding department of the business.

—o—

Mr. J. H. Stott, Lowfield Iron Works, Milnrow, near Rochdale, has been adjudicated a bankrupt.

LIGHT ALUMINIUM ALLOYS.*—II.

By J. E. Stacey Jones, B.Sc.

(*Concluded from page* 131.)

Founding of Aluminium Alloys.

Aluminium can be almost as easily cast as brass, if due care be taken in a few essential points.

If the metal is got too hot it is apt to take up silicon from the crucibles, or to get "burnt." The silicon will also be absorbed if a flux be used for melting, so that the universal practice is to use plumbago crucibles and not allow the metal to rise much above its melting point, which is about 650 degrees C., or 1,200 degrees F.

The surface of the molten metal becomes covered with a skin of oxide, and this prevents that underneath from oxidising. This oxide would be a mixture of aluminium and zinc oxides; it is impossible to skim it off permanently, because fresh surfaces exposed are at once themselves immediately oxidised.

Reverberatory furnaces are now largely used for the melting of aluminium in quantity, and they are useful too for remelting turnings.

If due regard be paid to avoid overheating, no doubt these furnaces offer a very convenient means of melting for a large foundry, and so far as I have come across them in use have been pronounced perfectly satisfactory.

Aluminium has a very high specific heat and also a high latent heat of fusion. This means that the metal takes a very long time to melt, and absorbs too a good deal of heat in the process of liquefaction. These properties are rather advantageous than otherwise, because the cooling down in the moulds will also require a considerable time.

Thus the fluid metal will leave time to let the oxide scum, that must of necessity accompany it from the crucible into the mould, rise to the top, and the fine lines in the casting will be well marked.

The shrinkage of castings is about $\frac{1}{4}$ in. to the foot, being 25 per cent. more than with brass.

With ingots or other large pieces, such as scrapped castings, etc., the loss on remelting is about $\frac{1}{2}$ to 1 per cent., but turnings and shavings will lose anything from 10 to 50 per cent., according to the way they are treated.

* Paper read before the Coventry Engineering Society.

"Burning."

The spoiling of molten aluminium by what founders term "burning" forms one of the greatest obstacles to careless workmen in the foundry, and is a source of very considerable annoyance also at present to those who have to buy the pure metal.

This condition in the former case results from the metal being allowed to get too hot, or to remain melted too long. The melted metal then absorbs certain gases from the furnace, and notably the gases of the atmosphere, nitrogen, and oxygen.

What is the cause of the large amount of "burnt" pure metal that is floating round this country at the time of writing is a little doubtful.

All that which I have seen so far has occurred in various shaped ingots, but in none of the forms which may be distinctly recognised as those of the Continental or U.S.A. Aluminium Works.

It all seems to have been remelted stuff, in which operation, of course, the "burning" may have taken place, though I suppose it is quite possible to get the same effect in a careless initial manufacture of the pure metal.

"Burnt" castings usually show themselves up in the machine shop, when, although the surface skin may appear quite good and satisfactory, the metal underneath is found to be full of minute holes, like a Dutch cheese.

(i.) *Physical Tests.*

Besides spoiling the machined part, there results from this cause a very serious loss of strength. I have already somewhat touched on this (Table II., columns C and D), when a sample of pure and good aluminium, giving a strength in tension of 6.1 tons, was reduced after artificial "burning" to 3.1 tons per square inch. Also (in the same Table II., columns A and B) figures were shown giving the relative strengths of "burnt" pure aluminium, and a 90 per cent. alloy made from this, as $4\frac{1}{2}$ and $5\frac{1}{2}$ tons respectively, when they should be about $6\frac{1}{2}$ and 10.

In the case of other samples from my own experience, I can show the same diminished strength (Table VI.). The alloy of the composition given were at first merely tested in the ordinary routine way, and not with any idea that their breaking strains would be below 10 tons per square inch. However, the low results obtained (5.9 and 6.8 tons) were so startling to the motor firm for whom they were done, that inquiries were set on foot in the foundry supplying them. The cause I found to be that the pure metal used to

make the alloys was undoubtedly "burnt," but unfortunately by that time nearly all had been put into castings, and could not be returned to the vendors. This was a case when the "burnt" metal did not show itself in holes when machining.

TABLE VI.—"*Burnt*" *Aluminium Alloys.*

—	No. 1.	No. 2.
—	Average of two concordant tests.	Average of two concordant tests.
Tensile strength: tons per sq. in. ...	5.9	6.8
Elongation on 2 in.: per cent.	3.0	2.4
Contraction per cent....	6.3	4.5
Aluminium ...	94.4 %	89.8 %
Copper	1.1	2.5
Zinc	4.0	7.1

(ii.) *Microscopical Appearance* (to the naked eye).

The *ingot-structure* of "burnt" metal, *i.e.*, its appearance to the naked eye, is often quite distinctive. We have:—

1st. A great profusion of spangled crystals on the top surface of the ingot, like those on galvanised iron ware which has been dipped in spelter containing tin. Slightly magnified, Fig. 3 shows one of these. The crystals are beautifully filicoid or fern-shaped, and occur on the good metal as well; but in that case there are only a few, and their size is nothing like that attained in a really "well-burnt" sample.

The opinion is consequently suggested that these crystals are always indicative of "burning," incipient or pronounced, and that perfectly good aluminium should show no crystals at all on the ingot-surface.

2nd. The centre of the top surface is usually not only sunk in like every cast ingot, but large cracks have appeared, traversing the crystals (Fig. 3 shows such a crack). In my own opinion, and also in that of other men who are qualified to say, these cracks are *absolutely indicative* of poor metal. I have never seen them in undoubted good ingots, and as a rough-and-ready test to differentiate (before subsequent examination) good from bad aluminium, the presence or absence of cracks is a good guide.

3rd. The top ingot surface is nearly always also covered with numerous parallel streaks, mainly at the edges. Fig. 4 shows a few, magnified 12 diameters only. The appearance is exactly that of a piece of skin, not caught evenly at the edges, which is pulled tight and "ruckles" up. I imagine that it is the skin of oxide on the metallic surface which does the same, and that the streaks are produced as a concurrent effect from the same cause which gives the central cracks.

We also get fine streaks sometimes on the good metal, but in nothing like the size and quantity that the "burnt" material shows.

The above three tests, therefore, will give the aluminium foundryman a good idea as to whether his metal is good or bad when it arrives, but, of course, none are absolute proofs. For this recourse must be had to the more scientific examination by physical, microscopical, and chemical means.

(iii.) *Microscopical Examination.*

For pure and alloyed aluminium I have used two methods of micrography. The first I employed was the ordinary one of examining a polished etched surface; the second of casting specially on a flat surface, and examining without further treatment.

1st. The method of micrographical examination by polished and etched surfaces I have not found a very great success with aluminium. In the first place it is very difficult to polish such a soft metal well, and in the second to etch well afterwards.

The only re-agent that will work fairly well is hot nitric acid (sp. gr. 1.2), in which the polished specimens are dipped for two or three minutes until etched enough; and to get good results I had to adopt the very unusual expedient of alternately polishing on rouge and etching. Thus the structure can be brought up gradually, but the stringent method of attack renders fine etching very difficult.

Fig. 5 shows (at 60 diameters) that the characteristic structure of pure (99 per cent.) aluminium is that of large hexagonal or octahedral crystals. (The division planes between the crystals are not actually filled up as shown in the photograph, but are very fine; the black substance shown is necessitated by the amount of etching required to show the crystals clearly enough.)

Fig. 6 shows a very similar structure for an alloy having the following analysis:—

	Per cent.
Aluminium	84.5
Zinc	10.0
Copper	4.6

We get the same shaped crystals, but much smaller, and we get actually here

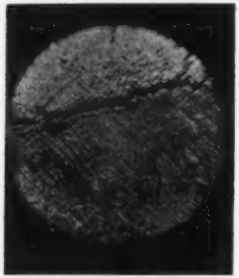

FIG. 3.

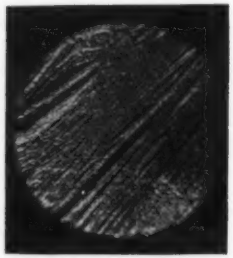

FIG. 4.

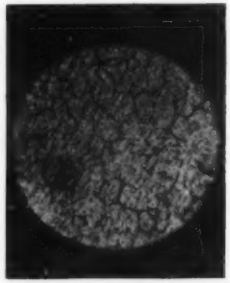

FIG. 5.

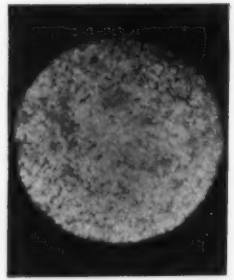

FIG. 6.

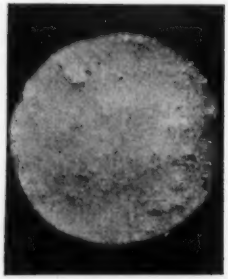

FIG. 7.

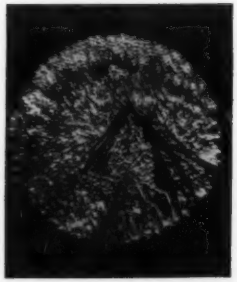

FIG. 8.

FIG. 9.

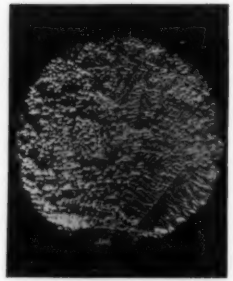

FIG. 10.

PHOTO-MICROGRAPHS OF STRUCTURE OF CAST ALUMINIUM.

Figs. 3 & 4.—Magnified 12 diameters. "Burnt" pure ingot, top surface as seen.
Fig. 5.— " 60 " Pure aluminium, polished and etched with nitric acid.
Fig. 6.— " 60 " Alloyed " 84·5 %, " " " "
Fig. 7.— " 12 " " " " cast quenched.
Fig. 8.— " 12 " " " " cast annealed.
Fig. 9.— " 12 " Good pure metal, cast quenched.
Fig. 10.— " 12 " "Burnt" " cast annealed.

the interstitial parts filled in with a eutectic, probably of a copper aluminium or zinc aluminium alloy.

So far with this way of examination I have been unable to detect any difference at all between good and "burnt" samples; and not much difference between alloys of from 85 to 95 per cent. pure. I therefore had recourse to the second method of examination, of the cast surface, *per se*. I melted a small quantity of the metal and alloy, and poured it on to a flat polished iron surface, the solid button being then treated in two ways. For the "cast annealed" structure the fluid aluminium was poured on to a plate made already hot, and allowed to cool by itself in the air; for the "cast quenched" structure I poured it on to a large cold mass of iron, and cooled in water as soon as the button was solid enough to pick up.

The two structures are quite distinct. With the annealed buttons we get quite large crystals comparatively, whereas the quenched ones show a fine, close grain.

Figs. 7 and 8 show the two structures of the same alloy as that used in Fig. 6. Quenched, we have no crystals standing out at all, but merely a fine grain uniform all over. (The protuberances are merely inequalities, here and in the following corresponding Fig. 9 of the cast surface.) The annealed structure (in Fig. 8) shows a fairly uniform cellular ground-mass under high powers, with needle-like (acicular) crystals radiating from points. I find that unless the cooling be done very slowly these needles do not form, or only rudimentarily.

In Figs. 9 and 10 we get the corresponding appearances with pure aluminium. The quenched metal is almost uniform, whether good or bad, while the annealed structure of "burnt" metal has always given me large filicoid crystals, as in Fig. 3. These are very well marked indeed, and in the good metal do not seem to appear at all, an uniform cellular grain similar to the alloyed metal above resulting.

It will be seen how the appearance of these crystals coincides with that of those on the surface of ingots of the "burnt" metal in Fig. 3. With metal that shows none on the ingot I have found none after re-casting, as above, while "burnt" material gives nothing else.

(iv.) *Chemical Examination.*

The ordinary chemical analysis of aluminium for copper, zinc, silicon, and iron, whether pure or alloyed, is practically useless to detect the "burnt" condition. I have repeatedly found two samples of pure metal to give almost identical results, when they have been as different from one another for foundry purposes as night from day.

This "burning" is usually ascribed to the absorption of the gases from the furnace, and nitrogen appears to be very active in this respect. This gas probably combines in some way with the aluminium to form a nitride, because when the metal is treated with acids, or caustic soda, this nitrogen is evolved as ammonia gas or its compounds.

This hypothesis that the nitrogen goes into combination is strengthened by the fact that "burnt" metal cannot be brought back to its original good condition by any method we are at present acquainted with. If the gases were simply absorbed by the metal, they would probably be wholly evolved again either on cooling or by some simple subsequent treatment, such as careful remelting.

It is highly probable that gases so absorbed in the furnace are in part given off again in the cooling process, and that it is to this evolution the minute holes found in some bad castings are due. We have the case of molten silver as an example: if this metal be kept for some time melted in an ordinary gas-furnace, where there is a good current of air, large quantities of oxygen are absorbed, but the oxygen does not enter into combination, and when the silver solidifies first on the surface, the oxygen bursts forth from the melted centre to produce volcanic-like craters.

In some experiments done recently (1906) to determine the relative amounts of nitrogen in "burnt" and good aluminium, the following results were obtained:—

TABLE VII.—*Nitrogen in Aluminium.*

Good metal.	"Burnt" metal.	Remarks.
Per cent. N.	Per cent. N.	
0.11	0.44	Same sample as in Table II., C and D, "burnt" purposely
—	0.38, 0.50	Delivered "burnt."
0.07	—	Satisfactory metal.
0.11	—	
0.12	—	
0.09	—	

Thus, so far as my experiments have gone, satisfactory aluminium seems to bear nitrogen of about the order of 0.1 to 0.15 per cent., which increases to three or four times as much when "burnt."

I am of opinion that this determination will prove of considerable value in its application, and intend to extend investigations in this direction.

Formation of Nitrides.—Recent researches on the formation of nitride of aluminium (J.S.C.I. 25[1100]) have proved that the most suitable temperature for such compounds to be produced is 700 degrees C., which is 80 degrees C. above the melting point, and that the maximum amount of nitrogen absorbed is 1.8 per cent.

Ammonia gas is the most active agent, and as this gas is present to a more than small extent in the coke-furnace gases, it seems possible for the nitrogen compounds shown to be present in aluminium that is "burnt" to have been formed by this means. The reverberatory furnace, with its use of Cannel coal, would contain good amounts of ammonia gas, either free or in combination, and thus much greater care should be taken to avoid overheating and excessive exposure of the flames.

A high percentage of nitrogen has been proved to be directly responsible for a diminished breaking strain, and in the spoiled metal under consideration is probably the chief factor in the reduction found to take place.

But I am also inclined to place almost an equal cause for the "burning" in the mixture of oxide of aluminium or alumina with the metal. In the sample of badly spoiled pure aluminium, referred to in Table IV., cols. A. and B., of which the tensile strengths were 4½ and 6½ tons per square inch respectively, in the pure and alloyed state—in this sample was found evidence during the analysis of the existence of about 0.6 per cent. of alumina.

Now, to the chemist, the determination of the amount of oxide in any metal is not an easy operation, and in aluminium it is most especially difficult. In this particular sample, and in the process usually used for the determination of silicon, I obtained a most peculiar white residue, which, on testing, was alumina (after all the silica had been driven off). This was quite unlike anything that I have ever got before in very many analyses, and was obtained every time the experiment was done, whether on the same ingots or different ones of the delivery. The amount was also nearly constant every time, about 0.6 per cent.

I proved this to be certainly alumina, but, of course, the question remained: was it present in the metal as alumina, or formed by oxidation during the experiment? There is no doubt but that small amounts of oxide are contained in all samples of alumina, but I personally am of the opinion that this particular sample had more than usual, though up to the present I have not had the opportunity of proceeding further with experiments to prove the point.

Work in this direction will probably in the case of aluminium, as in that of copper, throw a good deal of light on the usefulness, or otherwise, of metal for technical purposes.

To sum up, we have an analogy between aluminium and steel (with other metals) in considering whether or not any sample is good enough for use; we require three data, namely, chemical, physical, and microscopical examination.

In the chemical tests I assume, of course, that the ultimate composition—that is, the content of aluminium, copper, zinc, with other metals if present—is satisfactory. Special tests, such as I have endeavoured to outline, will show whether the amount of nitrogen is excessive, and will, I hope, soon enable us to say the same of the oxide present.

The physical tests will show whether the sample is suitable with regard to its strength, and I am bound to say, that as far as our knowledge goes at present, these tests are by far the most important if the composition of the pure metal or alloy is satisfactory. There is no getting away from the fact that if the tensile strength is too low, the aluminium is quite unsuitable for technical purposes, such as motor car work.

Our knowledge of the microscopic structure of aluminium is of the most meagre character at present, and affords much less ground for generalising or particularising than do the chemical analysis and physical tests.

I should be one of the last to dare to assert that the conclusions to be drawn from the micro-structures shown this evening, or, indeed, of the many others I have not been able to tell you about, are to be regarded as anything like final. Finality in any branch of science is impossible. Continued investigation must always lead to modified views, and there is certainly no technical subject in which more research seems to be needed than in the one which we have considered.

The opinions I have expressed with regard to my own experiments on special alloys and "burnt" metal are, of course, somewhat contentious, and it is with great pleasure and thanks that I should hear any member criticise them, or offer suggestions, as to future experiments.

Discussion.

The CHAIRMAN (Mr. A. P. Smith) invited discussion of the paper, and himself asked the lecturer if it was known what was the peculiar smell noticed on breaking the ingots of the metal? Also if he could enlighten them as to a really good method of melting up aluminium turnings?

MR. H. L. HEATHCOTE (Messrs. Rudge-Whitworth, Limited) asked if castings could not be obtained very good and strong by making them under pressure in metal moulds?

MR. F. H. HURREN (Rover Company, Limited), supported the lecturer's remarks as to the content of nitrogen and aluminium oxide in "burnt" metal from experiments that he had done himself. He instanced the case of a wonderful new alloy which he had lately looked up in the patent records. He found on working the composition that it would be about 66 per cent. of aluminium and 33 per cent. of zinc, with nothing else whatever.

He showed ingots, one of which had a crust of white oxide on its surface, and another a blue one of copper salts, and asked the lecturer what he would recommend as a cure for these, or a preventive?

MR. P. ROWLAND HILL remarked that all the B. A. Company's No. 6 alloys he had come into contact with showed about 85 per cent. of pure aluminium, which was the proper content according to the Company.

He also suggested that the determination of the elastic limit of the "burnt" aluminium would prove a good datum for its recognition.

MR. STACEY JONES, in reply, said that the smell noticed on fracturing ingots was generally assigned to the gas silicon hydride; it was quite evanescent, and lasted only a few seconds.

Turnings were at present best melted up by themselves in a large crucible, but, of course, there was a considerable loss, which might be very largely increased if care was not used. "Burnt" aluminium disposal was an important question; the best way was, of course, to do as one of the large Coventry firms had had to do lately, send it all back to the supplier. If this could not be done, practically the only way was to use it up bit by bit in the ordinary course.

In answer to Mr. Heathcote, he agreed that casting under pressure was very good, but unfortunately it meant expensive metal moulds, and the operation only paid when a large number of castings could be taken off the same mould. All sand castings were, of course, under some pressure.

To Mr. Hurren, Mr. Stacey Jones had to express his thanks for many suggestions which had been the beginning of some of his experiments. It was always very acceptable to have at hand in any fresh investigations someone who was interested in the same direction for advice and consultation. He suggested that the best way to keep the aluminium ingots from becoming covered with the white or blue scales would be to put them in water, or paraffin.

A vote of thanks to the lecturer was then passed, and briefly replied to.

TABLE VIII.—*Production and Price of Pure Aluminium.*

Year.	World's production.	Price.	Year.	World's production.	Price.
	Tons.	Per lb.		Tons.	Per lb.
1885 ...	3	50/-	1896 ..	1,789	1/4
1886 ...	11	42/-	1897 ..	3,394	1/5†
1887 ...	22	33/-	1898 ..	4,033	1/4
1888 ...	39	21/-	1899 ..	6,570	1/4
1889 ...	85	10 6	1900 ...	7,340	1/3†
1890 ...	171*	8 6	1901 ...	7,570	—
1891 ...	121	2/1†	1902 ...	8,100‡	—
1892 ...	485	2 8	1903 ...	8,000‡	1/4
1893 ...	713	3 1	1904 ...	10,000‡	1/4
1894 ...	1,057	2 1	1905 ..	12-15,000§	1/2-1/6‖
1895 ...	1,129	1/6	1906 ...	—	—

* Electrolytic manufacture commenced. † Fall in price due to electrolytic aluminium. ‡ Estimated production. § Production in U.S.A. alone in 1905 was 5,000 tons. ‖ Price 1/2 per lb. to August, 1905; gradually rose to present price.

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MESSRS. BILBIE, HOBSON, & COMPANY, engineers, have removed from 80 to 106, Queen Victoria Street, London, E.C.

THE STAVELEY COAL AND IRON COMPANY, LIMITED, have an order from the New Mills Urban District Council for 500 yards of 4-in. turned and bored cast-iron mains, with hydrants, valves, and specials, and 4,150 yards of 3-in. turned and bored cast-iron mains, with valves and specials. The contract price is £5 11s. 3d. for 3-in. and £5 10s. 10d. for 4-in. pipes.

MESSRS. PRINCEPS & COMPANY, engineers, Sheffield, have appointed Mr. G. Wright, Burnett Avenue, Scale Lane, Hull, as their representative for that district; Messrs. Ferguson & Timpson, Muscovy House, 6, Trinity Square, London, E.C., and 50, Wellington Street, Glasgow, for their respective districts; and Mr. W. H. Taylor as general traveller for the whole of Great Britain.

THE RATHBONE MULTIPLE MOULDING MACHINE.

THE economies in foundry moulding by machine as developed at the present day are brought more emphatically to notice by the perfection of the principle of multiple moulding. The development of this particular method has been slow, owing to the opinions against the apparent possibility of pouring castings in a stack of moulds without straining. Roughly, the development of this principle has been as follows:—First, it occurred to some one to put one mould on top of another, after cutting the sprue hole in the top mould through the drag of that mould, to reach the sprue of the bottom mould as a means of pouring, and it was found that by exercising a certain amount of care in the pouring the castings in the bottom moulds were as good as those in the top ones. The expected did not happen—the bottom mould neither burst, ran out, nor strained, nor did the bottom of the sprue cut up. This was explained by the fact that the metal in pouring did not fall with its full force directly to the bottom of the pouring hole, but, "wetting" the sides, reached the bottom mould fully as lightly as if it had fallen but one-tenth the distance from the open lip of a hand ladle.

That the bottom mould does not strain is due no doubt to the fact that by the time the metal has filled the next mould above and has risen to the level of the mould above that and filled it, when the head has become sufficient to do some straining, either the gate, due to its small section, or the casting in the lower mould itself, has set sufficiently to prevent the easy access of any more metal; so that as the pressure in the head increases so does also the resistance to its entrance into the lower moulds. Still, another reason for less straining than is expected in these bottom moulds lies in the fact that never were moulds so perfectly weighted and held as those at the bottom of a stack of moulds in iron flasks. It has been estimated that the pressure on the mould at the bottom of a stack 45 in. high is only about 12 lbs. to the square inch, and as the sand in these moulds

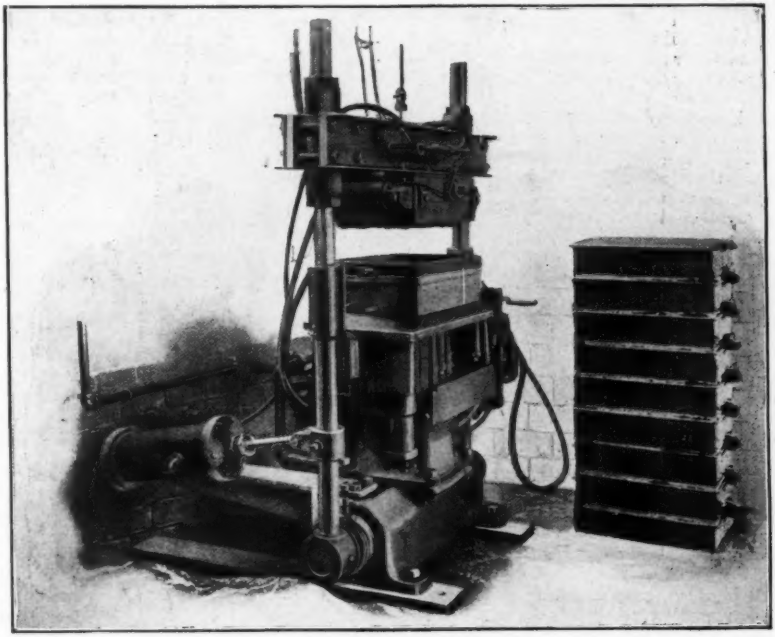

FIG. 1.—THE RATHBONE MULTIPLE MOULDING MACHINE.

has been rammed 40 lbs. to the square inch, the impossibility of the mould giving way is obvious.

The experiment of piling one mould on another worked so well that it was thought worth while to utilise all the joints in the stack for moulds. In fact, one of the great advantages of multiple moulding is that, except for single-faced cope and drag at the top and bottom of the pile, respectively, just half the sand and flasks are used that would be the case in ordinary two-part flask moulding. To accomplish a mould in every joint—that is, each single part flask with the cope for the mould below and the drag for the mould above, in the single block of sand—involved, it can be seen, ramming the sand up against the drag patterns, for only one filling can be made of a flask of loose sand into which must be rammed simultaneously the cope pattern at the bottom and drag patterns at the top. This necessity of ramming the drag patterns down into the sand, limited, for years, multiple moulding to a pattern having very flat drag parts. Some years ago A. K. Beckwith, Dowagiac, Mich., overcame this difficulty by placing his drag patterns in what he called a "receptacle," which he filled with sand upon the drag patterns, locking up, and then by means of a piece of sheet metal held the sand in this "receptacle" and in contact with the drag patterns while he inverted it and placed it over the flask already filled with sand upon the cope patterns on the machine. After withdrawing the sheet of metal from between the two bodies of sand he rammed the drag patterns down into the sand upon the cope patterns. This process made possible for the first time the multiple moulding of deep drag work, but necessitated in its operation the rolling over of the drag match or receptacle, etc.

Within the past year J. A. Rathbone, Detroit, Mich., discovered that by attaching the drag patterns to the oscillating ramming yoke of a power machine and giving the flask filled with sand an upward velocity, equal to that of sand falling from a shovel or riddle, he could place his sand up among his drag patterns to very considerable depths. By this method Mr. Rathbone makes a single filling and a single ramming from a complete mould in an incredibly short time, and 75 14 in. by 16 in. or 13 in. by 18 in. moulds have been made by one man in one hour's time, this man shovelling his sand from the heap and carrying off and stacking his own moulds.

Several power machines for this class of work, which are now in successful operation, have been designed and are now being placed before the trade by Messrs. J. W. Jackman & Company, of Caxton House, Westminster. One of these, shown in the accompanying illustration, Fig. 1, is of the usual power ramming split pattern vibrator type, with special attention given to solidity of construction and truth to centre line, with provision for accurately guiding the upper or drag patterns on the ramming block. To facilitate the swing of the ramming yoke a power cylinder (shown at the lower left of the machine) actuated by a small pop valve on the hand rail on the yoke is provided, even in the smallest size machines; whereas, usually power swing ramming yokes are not used in machines under 24 in. square. Both cope and drag patterns are heated with gas from local mains or a portable gasoline torch, and served by vibrators. All bearings are protected from sand and lubricated by closed cups. When this machine is working anywhere nearly at speed, and there are cores to be set, a second man is essential for this core setting, and as this man usually carries off the moulds from the machine its product is proportionately increased.

In operation, a flask, faced and pinned at both joints, is placed over the cope patterns on the machine, which are attached to the usual vibrated pattern plate. The ramming yoke of the machine is brought forward and a steel frame or "sand box" is released by two electromagnets or other retaining device, which holds it so that it drops upon the flask below. Riddled sand is then struck flush with the top edge of the sand frame. The ramming yoke, upon which are the drag patterns, is brought up again into ramming position. Air is admitted through the large throttle valve and the charge of air in a reservoir close to it is suddenly admitted to the cylinder of the machine. As a result of this sudden admission of air the flask, sand, and patterns are thrown violently up against the patterns upon the ramming yoke and the loose sand in the flasks rises among the patterns, filling deep pockets just as though it had been dropped or thrown down upon them. The sand thus placed all round the patterns has no opportunity to fall away from them, for it is caught and squeezed by the accumulating pressure in the cylinder. Thus both the cope and drag moulds are rammed simultaneously. The sand frame is made of such a depth that when its upper edge lands upon adjustable stops on the ramming block the joint face of the drag pattern plate is

flush with or above the top edge of the flask, and the mould is sufficiently rammed.

On difficult work, requiring hand tucking of the edges of the mould, the sand joint rises above the flask edges, but the result is equally good so far as the joints, etc., are concerned.

The vibrator for the drag patterns is automatically started as the machine rams, and as the flask and sand fall back with the ramming head of the machine the drag patterns are drawn from the sand, while the sand frame is removed by being held by the electro-magnets or other retaining device. The cope patterns and flask pins are now drawn from the bottom side of the flask and the mould is complete, cope and drag, in half a minute. The operator now carries off this first mould and places it, regardless of its bottom or cope face, upon a board or flat, firm bed, not soft sand.

The next mould is made in the same manner, except that the sprue for the mould now formed between the first and second flasks is cut through it automatically by the machine. So one mould after another is made until, determined mainly by convenience in pouring, the topmost one is in position, when a larger pouring basin is shaped upon it and, if thought best, a pouring weight is added. Except for the top mould no weight is needed, as the lower mould joints are made good by the weight of the upper moulds upon them. Printing back on these machines consists of a mere matter of shaking facing on the mould from which the patterns have just been drawn and ramming them into the mould again, without the exercise of any skill by the operator, and is done in a few second's time. As has been said, it is generally supposed that the lower moulds must be strained by the head of the liquid metal above, but, by a judicious apportioning of the section of the gate to the massiveness of the casting, it may be caused just to feed it without straining it, and, for most of the work for which multiple moulding is suitable, it is sufficient that the gate should be thinned down so that it has set by the time the second mould above it has filled, and the head is on the point of being increased by the filling of the sprue above.

The economies of this method of moulding are confined to speed alone. In stacking nine moulds for pouring, as in this method, it is evident that nine moulds occupy the floor space of but one. The ramming of the cope and drag parts in one flask also results in a saving in the sand used, but, as the flasks for multiple moulding average about 15 per cent. deeper than those for ordinary moulding, the actual net saving in sand and flasks may not be assumed to be greater than 37 per cent. A stack of castings made by the multiple process is shown in Fig. 2, which are 1 in. by ¾ in. by ½ in. grey iron tees, the total number of castings being 72. Castings from opposite ends of the gate in each mould were broken off for comparison in weight, which is shown in ounces in the following table, No. 1 being at the bottom of the stack:—

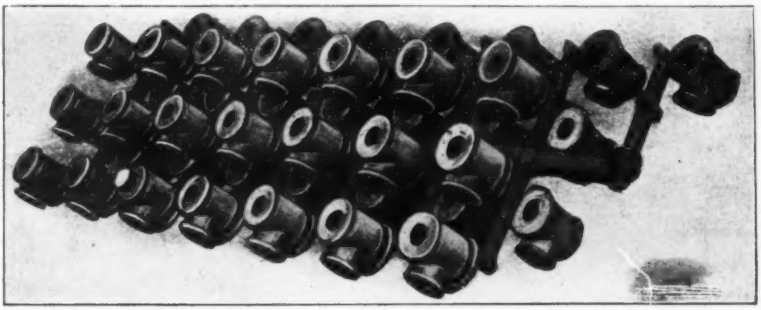

FIG. 2.—STACK OF CASTINGS MADE BY THE RATHBONE MULTIPLE MOULDING MACHINE.

	Vertical row. A.	Vertical row. B.
8	17¾	18
7	18	18
6	18⅛	18
5	18	18⅛
4	18⅛	18⅛
3	18⅛	18⅛
2	18⅛	18⅛
1	18	18

Equally good results are obtained in

small steel and malleable castings, as well as in brass plumbers' goods. At present Messrs. Jackman & Company is making these machines in three sizes, taking in flasks 13 in. by 18 in., 14 in. by 16 in., and 16 in. by 16 in., although larger or special sizes will be built if so desired. One of these machines is to be seen at Messrs. Jackman's Manchester warehouse.

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BRITISH FOUNDRYMEN'S ASSOCIATION.

The Birmingham Branch.

A meeting of the Birmingham Branch of the British Foundrymen's Association was held at the Technical School, Suffolk Street, Birmingham, on Saturday evening, March 16th, to hear a paper by Mr. H. Pilkington, M.I.C.E., President of the National Association, on the subject of "Pig-iron Specifications and Sampling from a Maker's Point of View." There was a large attendance, presided over by Mr. R. Buchanan, the local President.

The CHAIRMAN, before introducing the reader of the paper, nominated Mr. A. H. Hiorns as an honorary member, in recognition of his great services to the Branch. This was seconded, and carried with great acclamation.

The CHAIRMAN remarked that Mr. Pilkington had an unusual qualification in being, not only a blast furnace manager, but also an iron founder, the two positions being generally supposed to represent diverse interests. He was equally qualified from the scientific and practical points of view.

MR. H. PILKINGTON, after congratulating the Birmingham Branch on its growth and signs of prosperity, said he should not be slow to take up the challenge which the Chairman's remarks seemed to suggest, and they would discuss the various points of view with the greatest good feeling. Buyers by analysis were so rare and so varied in their requirements that they were practically a negligible quantity. Grade and grain were the matters of greatest importance in the pig-iron trade. To deal in pig-iron by analysis alone was quite impossible at present. It was well known that the temperatures at which the iron left the tapping hole had a good deal to do with the character of the metal. It was quite possible to make pig-irons of equal composition behave quite differently. Most of the difference was due to a change in the crystallisation brought about by different cooling temperatures. Much trouble arose from the varying nature of the materials employed. The fuels varied considerably, and the same was true of the ores and limes used, while the moisture in the air varied not only with the atmosphere, but according to the absorbing power of the coke. It was impossible to regard foundry pig-iron as anything but a crude iron of variable composition. They were dependent also on skilled ability in the workman. But of late years there had been no lack of scientific management. Whereas steel had a large amount of work put upon it, cast-iron was still similar in composition to the pig iron used. It must be admitted that fracture in itself was not a reliable guide to the composition of the metal, and some improved method of grading was desirable. But in discovering that new method, authors always failed to recognise the commercial possibilities, and the worst possible thing that could happen would be to abolish grading by fracture. The effect would be to produce a larger number of wasters. The fracture method could not be abandoned until some method of physical or microscopical classification was introduced, and that would require the assistance of chemical analysis. The best method was that in use in America, which was that of classifying by the fracture number and the silicon content in the known brands. If that were adopted it would be a definite step in advance. But it involved a higher price for the trouble and expense of selection, and they must remember any selection would inevitably lead to increased cost. But they must also remember that that method was only applicable to known brands of iron, and they were well aware that certain districts produced a similar class of iron. There was not much difference between the various works in the same district, and the difference was due to slightly different contents in manganese and phosphorus in the local ores. The duplicate method of grading by fracture and silicon would stereotype a regular percentage of sulphur in all the grades. But the specification of silicon alone was utterly useless for the grading of foundry iron, and high silicon might be present in hard and soft irons of the same brands. Very grey iron may be characterised by high combined carbon, sometimes amounting to 1 per cent., while the sulphur was low down to .005, which was practically negative. Those irons were extremely unsatisfactory to work, and those fluctuations were of more frequent occurrence than many people supposed. Far too much reliance was placed upon the analysis, which very often represented only a piece of iron specially subjected to test which by no means represented the whole, and variations were very great between the middle and the beginning of the cast. The sampling should be supervised personally by the chemist himself. The greatest fluctuations were concentrated on combined carbon, and they were extremely wide and erratic. But the percentage of combined carbon was one of the most important things, as it determined to a large extent the hardness, softness, or

strength, and this depended again upon the temperature at which the metal left the tapping hole, and the rate at which it cooled down. The combined carbon from the large and small furnace would differ very much, and would differ also in different parts of the same cast. Pig-iron should be graded by the percentage of silicon in each number, and the selection for particular purposes should be made by the selection of the mark of a certain district or brand to get the correct phosphorus and manganese content required. In America, the silicons were much lower in their pig-iron than in this country, and were often far too low for good work. They were nearly all of a more or less hematite character, carrying much lower phosphorus. It would necessarily be a long time before all founders got even as far as he had suggested in his paper, and when iron founders generally fell into line on the question of specifications, it would then be time for the blast furnacemen to consider what was to become of the iron which did not comply with that standard.

Mr. Parker, opening the discussion, said he agreed that when they were buying on a number, they should decide what districts they were going to for their phosphorus and manganese. They rarely got a high sulphur in No. 1 iron, but they expected it in a high number. His experience was they did not have much trouble with the grain unless they were working large castings, but serious trouble arose through the practice of throwing water on the pigs to cool them, so as to make way for the next cast, and while that continued as it did in the North of England they would never get uniform results. Sometimes the trouble was overcome in regard to silicon by having a mixer between the pig bed and the blast furnace. With regard to buying from districts, if they wanted a high manganese they must go to Scotland or an Eastern county, and for a low manganese with high phosphorus either Staffordshire or Northamptonshire. The variations in phosphorus were not of very great account. He would like to know what was the output per cast from a modern furnace and also the size of the mixer?

Mr. Haggi pointed out that the basic people must have the same difficulty as other smelters in specifying by analysis, but they did it. Analysis was manifestly necessary, because it was so difficult to get two samples alike.

Mr. Walker said his own experience told him they would get led astray by fracture, and his firm had had a lot of trouble for years, the metal very seldom coming up to the promises of the travellers. He did not think they were far from the time when they would buy by analysis. But the question of buying from districts was affected by the price. Their employers were very apt to follow a district where prices were lower.

Mr. Mason thought the objection to sell by analysis was due to the concern of the blast furnaceman on the question what he was to do with the bad stuff. The residue was the bugbear. It was very interesting to learn that the temperature of the tap hole had an influence over the physical qualities of the iron. The lecturer had insisted on high temperature, but the foundrymen got into trouble because they burned too much coke.

Mr. Shaw said that engineers asked not for chemical analysis, but for chemical tests, and he knew five cases where not one of the irons came to the required standard. He should like to know how it was possible to apply a practical test in the case of cast-iron pipes. He was very much impressed with the fact that American buyers got an analysis even in British iron. If the Yankees could have that, why could not Englishmen?

Mr. Parker pointed out that the latest idea was to freeze the moisture out of the blast before it went into the furnace, and he understood that had been very successful in America, though the expense of laying down the plant was considerable. He believed it would become as common as the use of dust catches, etc.

The Chairman said Mr. Shaw was quite correct about Middlesbrough makers having supplied an analysis. One of them was very wroth over the suggestion, but gave in when he found that was the only way to make a deal. His mind opened under pressure of circumstances. Within the last few days a maker he had applied to refused to be bound down to analysis, and he withheld the order. He was not altogether in accord with Mr. Pilkington or Mr. Parker as to the importance of combined carbon as indicating other constituents. Combined carbon was wholly conditioned by the other constituents, plus the rate of cooling. When they melted their iron the combined carbon was in solution, and the percentage that would come out of solution as graphite depended on the other constituents and the cooling. In foundry work as well as in blast furnace work they depended upon personal skill and knowledge. He went all the way in support of analysis, and it was the rarest occurrence to find any distinct difference between the definite analysis of iron and the physical characteristics, and they could supply the exact constituents for certain tests, and had done so a hundred times. He did not agree with Professor Sexton in the statement he made some time ago that Scotch pig-irons had altered their character within the last twenty-five years. That might be true of certain furnaces, but the general deposits had not changed. At the same time, the foundryman could not know when iron was altered unless he analysed.

Mr. Pilkington, replying, said he had seen huge mixers in front of the tap hole at Buffalo, America, placed at a short

distance, so that they were subjected to certain arrangements for controlling the flow. If the iron could be suddenly projected into the sand moulds they would have a more constant composition than at present. With reference to water cooling, he had followed that up to a considerable extent, and upon some of the casts the men were in the habit of turning the hose pipe, the effects of which was to cause cracks on the outside. One sample he saw a little while ago had its combined carbon materially altered. They could either drive out or drive in carbon with the iron in a solid state. As to the size of cast at blast furnaces it varied from ten tons to sixty tons as the maximum for a large modern furnace. He was aware of the experiment for freezing the water out of the blast, and on the question of moisture in the atmosphere he had had a number of records taken which showed very serious variation indeed. There was great difference between a frosty day in winter and a moist day in summer, which would affect the fuel consumption. This was more serious in England than in America. He had minimised it by enclosing the blowing cylinders in tubes. The question of economy was not clear, because the freezing process was so costly, and he would hesitate to go further until they had more data. It was not correct that what could be done with basic could be done with foundry iron, because the latter was so much less pure, and another difficulty arose from the difference between the rapid and the slow driving furnace. They would have lower silicon with a rapid driving furnace than with an old-fashioned slow driving one. Blast furnacemen were not against analysis, *per se*, if any basis could be arrived at which would enable them to deal with anything like the bulk of the iron. Like Mr. Buchanan, he was disposed to challenge Professor Sexton's statement as to district brands. Although it was true that certain furnaces were using different material, both Scotch and Derbyshire iron retained their essential characteristics. It was quite true that the silicon would be lower in the bottom part of the furnace than in the upper part, where the metal was hotter. He had never seen any explanation of that. As to air moisture the effect of that would be less upon the cupolas than upon blast furnaces because they were smaller. But he did not know why they should blow cupolas with cold air instead of using hot air as they did with blast furnaces. As to coke consumption, he thought it more important to have hot iron than save a few pounds of coke. It was quite true that English iron had been sold by analysis to America, and that could be readily done with No. 3 Cleveland because they were the most regular ores with which he was acquainted, and they could depend upon the composition if they knew the silicon content.

In conclusion, he would say that it would assist regular working in blast furnaces if a common agreement within limits were arrived at as to the best method of grading pig-iron. It would force a certain amount of selection in materials which was not a commercial factor to-day. (Applause.)

The proceedings concluded with a vote of thanks to Mr. Pilkington, which was briefly acknowledged.

—o—

PATTERN FOR GIRDER PILLAR.

HOWEVER simple a job may appear to be after it is finished, there is many a time when the end has only been attained through either a great amount of thought or gradual development. This fact is very often overlooked, and we are apt to value the result according to the light in which we look at the finished

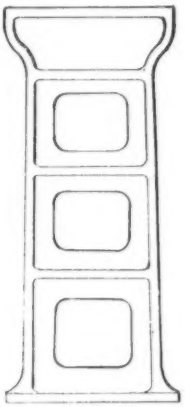


FIG. 1.

article, and the only credit given for it is: "Well, the thing is simple enough; anyone could do the same." So they might, if they knew how. At other times the result is, perhaps, the other way about, and the solution or idea of doing the job comes as a sudden inspiration; but even in the latter case the solution may only have been possible to someone having an association of ideas gathered together during the course of a long training in the subject pertaining to that idea.

The method of doing the work which forms the subject of this article may be put down to either of these causes, but, as a matter of fact, the latter is the true one.

In the first place, what was wanted was eight pillars to the shape shown in Fig. 1—Fig. 2 is a front elevation—and six others to the shape of Fig. 3, with Fig. 2 again as front elevation. The drawing for these was issued with the understanding that it would be necessary to make two patterns. Fig. 1 was for carrying the crane traverser girders in the centre of the shop. Fig. 3 was for the same purpose, but had to go against the wall.

Looking carefully into the design of these pillars, it will be noticed that each have certain features common to both, the principal difference being that the one pillar is only about half the width of the other, and that the narrow one is full width, and the frame fixed in between. There are two reasons for this, first, ease of fastening; second, there are no joints to overlap, with a consequent pulling up of the sand; for the same reasons the end flanges *c*, *c*, are made in a similar manner, but with the grain running in the direction of the way in which the pattern is drawn from the sand. The sketch, Fig. 4, gives a good idea as to how the pattern was put together.

As already stated, the two pillars have certain features common to both, but if the wall pillar, Fig. 3, would have done with the open part to the front, the rest of the job would have been simple, for in that case all that was required was the

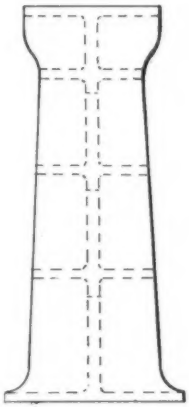


FIG. 2.

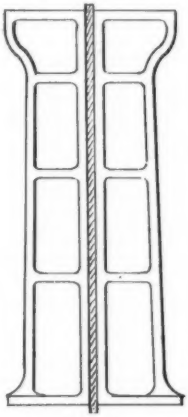


FIG. 3

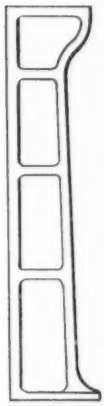


FIG. 4.

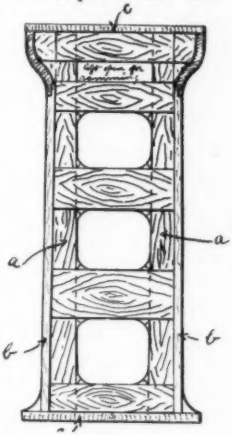


FIG. 5.

plated, and has a flange down the back where it fits against the wall.

The question now is: What is the best and most economical way of making these patterns? And in considering these two points, the idea comes in that it might be possible to make one pattern do for both; by making a little alteration in the drawing it was found possible to do this in the following way:—

The pattern was first made for the large pillar; two strips *a*, *a*, Fig. 4, the required length and width were sawn out and machined to size; these were then marked for half lapping, as shown in Fig. 4. It will be noticed that when the cross-pieces are placed in position, the framework is formed so as to leave the spaces the right size, and ready for the corner-pieces.

The side flanges, *b*, *b*, were cut to the pattern ramming up to the top of the centre plate, the remaining portion being stopped off, making a flat cope; but the pillar was required with the plated part to the front, which, of course, makes the job more difficult.

After consultation with the foreman moulder, and getting his opinion as to the best way of carrying out the idea, it was decided, after the eight large pillars were cast, to prepare the pattern so as to make two moulds at the same time. To do this, a flange was fixed down the centre of the pattern, of a sufficient thickness to allow for a core to be put in between, which would leave the flange 1½ in. thick on each side; these flanges thus formed the back of the pillars. Fig. 5 shows how this was done.

The whole pattern was then rammed up in the usual way, and when the centre

cores were put in, the mould was practically divided into two sections; preparation was made in the cope so that both parts could be filled together, and so relieve the strains there would be on the cores.

The six pillars were cast without a hitch of any kind, and cost much less than if they had been moulded and cast separate. Credit is due to the foundry department for the way in which the job was carried through.

LIST OF NEW INVENTIONS.

Specially compiled for THE FOUNDRY TRADE JOURNAL by MR. GEORGE BARKER, Fellow of the Chartered Institute of Patent Agents, Consulting Engineer and Chartered Patent Agent, 77, Colmore Row, BIRMINGHAM.

4,180. ALLEGEMEINE ELEKTRICSTATS GES. Improvements in centrifugal pumps or compressors.

4,365. ALLEGEMEINE ELEKTRICSTATS GES. Improvements in centrifugal pumps or compressors.

4,366. R. SCHERFENBERG. Bricks for, and an inside structure for, reaction towers.

4,785. W. REAVELL. Regulating devices for multi-cylinder compressors.

4,913. F. WALENTA. Process for the production of casting patterns.

5,966. A. GREEN. Improvements in moulding machines.

6,166. R. C. HARRISON. Improvements in and connected with rubbing bricks, blocks, wheels, and the like.

6,368. J. SOUTHALL. Improved base for tramway poles.

14,837. 1906. W. COLLINS, Tipton, Stafford. Improvements in moulding boxes.

This invention relates to the construction of moulding boxes for the production of repetition work, either hand or machine-made, as used in foundries for manufacturing small castings in iron, brass, or other metals. Its construction facilitates the removal of the box from the mould when the sand has been rammed into its required shape, thereby conducing to better results and occupying less time in the moulding.

As shown in the figures, the box is of rectangular form in plan, and is made in two parts A and B. The part A fits over B, and the whole tapers towards the top. The top half is provided with a groove C, or channel running along the inside faces of the two long sides, the grooves terminating in circular openings at both ends of the box. A half round hollow bolt D fits easily within each groove, and has a bearing in the said openings. Handles E are mounted on one end of the bolts D at the front end of the box, by which means the bolts are partially rotated by hand. The rotation of the bolt is limited to a half-turn by stops, and the bolts are prevented from moving longitudinally by a screw I.

When it is desired to make a mould

FIG. 1

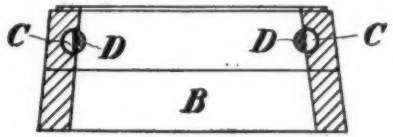
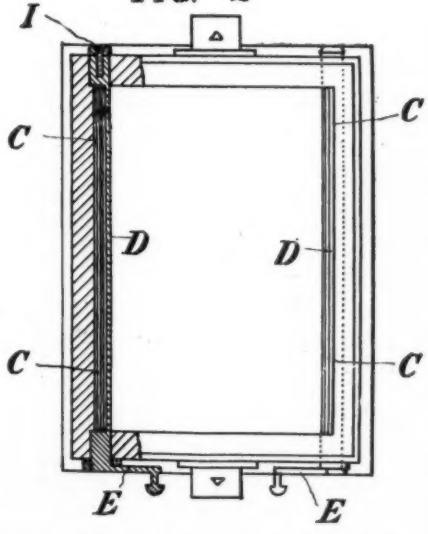


FIG. 2



from a pattern, it is put in the lower half and the top part is then fitted on.

The handles are turned so that the bolts project into the top half, as shown in Figure 1. The sand is then put in and rammed down hard. When this is done the top half may be lifted off, the pattern taken out and the top replaced. Another turn of the handle slips the bolts back into the groove and the top casing may then be removed, and leave a clear pile of sand ready for casting.

CORRESPONDENCE.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I should feel obliged if any of your readers could supply me with information as to a good mixture for making hammer stamping blocks for locomotive spring links, etc. They should have a hard face and to withstand heat, etc. We have been using half hematite, quarter No. 3 Cleveland, and quarter scrap. This is too soft, as the faces murl away and crack. Would an addition of steel turnings harden and toughen the faces?

Yours, etc.,
W. A. H.

STEEL MIXTURE.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—Can any of your correspondents give me a steel mixture suitable for ammonia valves.

Yours truly,
SUBSCRIBER.

GAS IN TAPPING METAL.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—In reply to query in your last issue, the gas or gases in tapping metal are generated in the furnace; letting the molten metal stand in a ladle for a little while has a good effect upon its character. The gases taken up in the melting process thereby have a chance to escape, and the accompanying manganese and silicon can combine with the iron oxide brought into solution in the furnace in considerable quantities, and destroyed by forming oxide of manganese and silicic acid, which, having a less specific gravity, will rise to the surface in the form of slag. The carbon in solution also acts upon the protoxide. From this gaseous carbon-dioxide is formed, which escapes from the metal and is consumed in the atmosphere. The sulphur drawn from the coke in the melting process, and also that which may have originally been contained in the iron, reacts upon the manganese and forms sulphide of manganese, which also rises to the surface and contributes to the formation of slag. All these influences of foreign particles of the iron upon the oxygen in solution and the sulphur aid in securing a perfect casting. They are all the more perfect in proportion to the temperature of the metal, and it is therefore necessary that the cupola should turn this out at a slightly higher temperature than is necessary for pouring. Dull iron cannot be purified in the same measure, for its lack of fluidity retards the egress of the impurities and gases which have been released and formed; hence these do not rise wholly to the surface, and the casting will contain flaws.

Faithfully yours,
Worksop. CHAS. E. ALLEN.

TRADE TALK.

THE LINWOOD FOUNDRY COMPANY, of Linwood, near Paisley, has been dissolved by the retirement of Mr. R. R. Wilson.

SIEMENS BROTHERS DYNAMO WORKS, LIMITED, have opened a London branch at 1, Abchurch Yard, Cannon Street, E.C.

MESSRS. W. T. PEARSON & C. J. FISH, engineers, Wellingborough, trading as Fish & Company, have dissolved partnership.

A FIRE broke out recently at the engineering works of John Hetherington, Limited, Manchester, doing considerable damage.

MESSRS. EVANS BROTHERS intend erecting a large engineering works near the Great Western Railway Station, Morriston.

MESSRS. A. & J. M'CULLOCH, 140, West George Street, Glasgow, have been appointed Scottish representatives of Tubes, Limited.

AN outbreak of fire occurred recently on the premises of the Star Foundry Company, Limited, Blyth, but very little damage was done.

TAYLOR BROTHERS & COMPANY, LIMITED, Clarence Iron Works, Leeds, have decided to remove their business to Trafford Park, Manchester.

THE MIDLAND MANUFACTURING COMPANY, LIMITED, of Sheffield, have purchased the business of the Premier Engineering Company.

MESSRS. JOHN NEEDHAM & SONS, of Needham Chambers, Old Millgate, Manchester, have removed to 44, Brown Street, Manchester.

MESSRS. C. MERRICK & SONS have lately put down a new plant for the manufacture of brass and bronze castings at their works at Cork.

MESSRS. BLACKSTONE & COMPANY, engineers, Stamford, have established London offices at 81, Cannon Street, E.C., and 4, Budge Row, E.C.

MESSRS. POLLOCK & MACNAB, Britannia Machine Tool Works, Bredbury, Manchester, contemplate making considerable extensions to their works.

EDGAR ALLEN & COMPANY, LIMITED, Sheffield, have appointed Mr. P. T. Taylor, 89, Clarence Street, Sydney, as their sole Australian representative.

MESSRS. L. S. D'ISZORO and R. T. FINLOW, engineers, Stockport, Cheshire, trading as the Aqua Engineering Company, have dissolved partnership.

MESSRS. J. GRAY & COMPANY, 212, St. Vincent Street, Glasgow, have been appointed sole representatives for Newtons, Limited, in the West of Scotland.

THE BUTTERLEY COMPANY have secured an order from the Kettering Urban District Council for cast-iron pipes and specials to the value of £332 6s. 2d.

THE STANTON IRONWORKS COMPANY, LIMITED, are supplying cast-iron pipes and other castings to the Metropolitan Water Board at a cost of £5,911 9s. 2d.

MESSRS. AITON & COMPANY, ironfounders, Western Works, Hythe Road, Willesden Junction, London, N.W., have decided to establish new works at Derby.

MESSRS. L. H. LUCY & COMPANY, Botolph House, 10, Eastcheap, E.C., have been appointed sole London agents for the Horbury Junction Iron Company, Limited.

HADFIELD'S STEEL FOUNDRY COMPANY, LIMITED, have introduced a new type of projectile, which, according to Sir Howard Vincent, will pierce any armour yet made.

THE HOLWELL IRON COMPANY, LIMITED, of Asfordby, near Melton Mowbray, are supplying cast-iron pipes and special irregular castings to the Metropolitan Water Board.

THE BRITANNIA ENGINEERING COMPANY, LIMITED, Britannia Works, Colchester, have added three new bays to their works, comprising light and heavy machine shops, smithy, tool room, turnery, and pattern shops.

AT an adjourned meeting of the creditors of the Hercules Engineering Company, Limited, which was formed for the purpose of acquiring the business of the Queen's Engineering Works, Limited, Holbeck, Leeds, the matter was left in the hands of the Official Receiver.

IN connection with the dissolution of Messrs. G. B. Smith & Company, we understand that Mr. G. B. Smith is carrying on business as G. B. Smith & Company, at the Phœnix Iron Works, Govan, Glasgow, and Renfrew Chambers, 126, Renfrew Street, Glasgow, assisted by his son, Mr. G. B. Smith, junr.

—o—

NEW COMPANIES.

UNION FOUNDRY COMPANY, LIMITED.—Capital £2,000.

S. ILLIDGE & SON, LIMITED.—Capital £10,000, to carry on the business of brass and ironfounders, etc.

LONSDALE ENGINEERING COMPANY, LIMITED.—Capital £2,000. Registered office: 27, Chancery Lane, W.C.

EMERY SYNDICATE, LIMITED.—Capital £10,000. Registered office: 46, Devonshire Chambers, Bishopsgate, E.C.

BELL RANGE AND FOUNDRY COMPANY, LIMITED.—Capital £25,000. Registered office: 1, Gold Street, Northampton.

NORTHAMPTON MACHINERY COMPANY, LIMITED.—Capital £15,000. Registered office: St. Michael's Road, Northampton.

APPLIANCES AND GENERAL ENGINEERING COMPANY, LIMITED.—Capital £15,000. Registered office: 3, Rosebery Avenue, E.C.

E. JAMES & COMPANY, LIMITED.—Capital £1,000, to acquire the Falcon Foundry, Thomas Street, Walsall, of E. James & Company.

MELKSHAM ENGINEERING COMPANY, LIMITED.—Capital £20,000, to acquire the ironfounding business of Tilke & Smith, Limited.

LONGWORTH & COMPANY, LIMITED.—Capital £5,000, to carry on the business of ironfounders, etc. Registered office: Elgin Street, Belfast.

JAMES LUMB & SONS, LIMITED.—Capital £20,000, to take over the business of Messrs. J. Lumb & A. Lumb, Perseverance Engine Works, Eland.

COVENTRY SIMPLEX ENGINES, LIMITED.—Capital £3,000, to take over the business carried on at East Street Works, Coventry, as the Simplex Engine Company.

HENRY J. COLES, LIMITED.—Capital £25,000, to acquire the engineering business formerly carried on by the late H. J. Coles at the London Crane Works, Derby.

NEW MOULDING MACHINE.

PICKLES' PATENT.

ASK FOR LIST AND FULL PARTICULARS.

COMPLETE FOUNDRY EQUIPMENT.

JAMES EVANS & CO.,

Britannia Works, MANCHESTER.

TELEGRAMS: "LADLES, MANCHESTER." "BLACKINGS, GLASGOW." TELEPHONE: 2297, MANCHESTER. 3185, BRIDGETON, GLASGOW.

FISHERS, LIMITED.—Capital £10,000, to acquire the engineering business of Messrs. Fisher & Company, Paisley. Registered office: St. Mirren's Engine Works, Paisley.

M'ALPINE & COMPANY, LIMITED.—Capital £10,000, to acquire the business of M'Alpine & Company, engineers. Registered office: Thistle Works, Campbell Street, Govan.

T. & J. HOSKINS, LIMITED.—Capital £6,000, to acquire the business carried on at Dock Head Iron Works, Bermondsey, S.E., as T. & J. Hosking. Registered office: Dockhead Iron Works, Bermondsey.

CRADLEY HEATH MANUFACTURING COMPANY, LIMITED.—Capital £2,000, to acquire the business carried on at Surfeit Hill Works, Cradley Heath, Staffordshire, as the Cradley Heath Manufacturing Company.

PERSONAL.

MR. W. G. KENT has been elected chairman of Evered & Company, Limited.

MR. A. E. L. CHORLTON has been elected on the Board of Mather & Platt, Limited.

THE late Mr. J. Rowan, of Messrs. D. Rowan & Son, Glasgow, left personal estate valued at £39,443.

ADMIRAL SIR ARCHIBALD L. DOUGLAS has been elected a director of Hadfield's Steel Foundry Company, Limited.

THE late Mr. H. H. Eadon, of Messrs. Henry Eadon & Sons, High Bridge Forge, Owlerton, Sheffield, left £7,125 gross.

THE value of the personal estate of the late Mr. D. Bonar, of Messrs. Douglas & Grant, engineers, Kirkcaldy, is £18,069.

THE gross value of the estate of the late Mr. R. Witham, of Messrs. Witham & Sons, Perseverance Iron Works, Leeds, is £1,456.

THE late Mr. A. Drennan, secretary of the Anderston Foundry Company, Limited, left personal estate to the value of £16,027.

MR. J. G. KINCAID has been appointed convener of the Engineering and Shipbuilding Section of the Greenock Chamber of Commerce.

MR. J. T. RUBERY, ironfounder, of Walsall, and Mr. C. Tildesley, ironfounder, of Willenhall, have been made J.P.'s for Staffordshire.

MR. H. R. C. PARTRIDGE has been appointed manager of the Thornbury Works, Bradford, of the Phœnix Manufacturing Company, Limited.

MR. A. T. JENKINS, of Messrs. R. Jenkins & Company, boilermakers, Masborough, has been added to the Commission of the Peace for Rotherham.

MR. J. WARD, of Messrs. Wm. Denny & Bros., Dumbarton, has been nominated as President of the Institution of Engineers and Shipbuilders in Scotland.

MESSRS. P. CURRIE, J. FLETCHER, and G. A. DUNSMUIR have been given an interest in the business of Dunsmuir & Jackson, Limited, engineers and boilermakers, Govan.

MR. F. B. NATHAN, manager of the supply sales department of Siemens Brothers Dynamo Works, Limited, has resigned in order to take up an appointment with Joshua Buckton, Limited, Leeds.

MR. H. BRIGGS, the Johannesburg representative of the Sandycroft Foundry Company, Limited, 6, Queen Street Place, London, E.C., has been elected a member of the Transvaal Legislative Assembly.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

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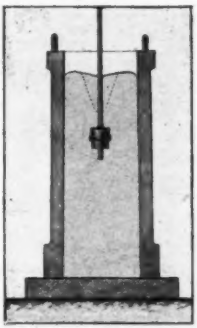

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ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1906-7.	1905-6.
Iron—Scotch pig warrants ... ton	*61/0	—
—Middlesbro' warrants ... ... ton	53/5	45/6
—W.C. M/nos Bessemer ... ... ton	78/6	67/6
—Stock, Scotch, Apl. 4 ...tons	4,390	14,000
Copper—Chili bars, GMB ... ... ton	£92 2/6	£84 12/6
—Stock, Europe & afloat... ... tons	15,007	9,016
Tin—English ingots ton	£187 0/0	£172 10/0
—Straits ... ton	£182 15/0	£174 5/0
—Stock, Ldn. Hind and afft ... tons	12,921	12,353
Lead—English pig ton	£19 12/6	£17 10/0
Spelter—Ord. Silesian ... ... ton	£26 0/0	£29 7/6
Quicksilver—(75lb.) bottle	£7 0/0	—
Antimony—Regulus ... ... ton	£100-£103	£63-£64

*Settlement price.

Castings.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	7 0 0	to	7 5 0
Pipes, 1½ to 2½ in.	5 10 0	to	5 15 0
,, 3 to 4 in.	5 2 6	to	5 10 0
,, 5 to 8 in.	5 0 0	to	5 2 6
,, 10 to 16 in....	5 0 0	to	5 2 6
,, 18 to 24 in....	5 0 0	to	5 2 6
Chairs	4 2 6	to	4 5 0
Floor plates (open sand)	3 5 0	to	3 7 6

Scrap.

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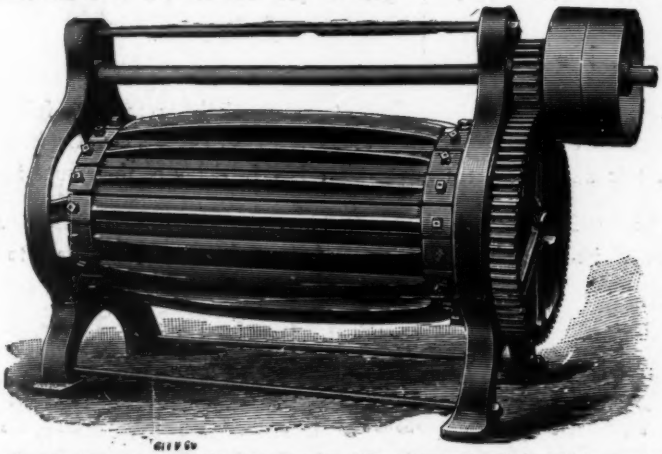

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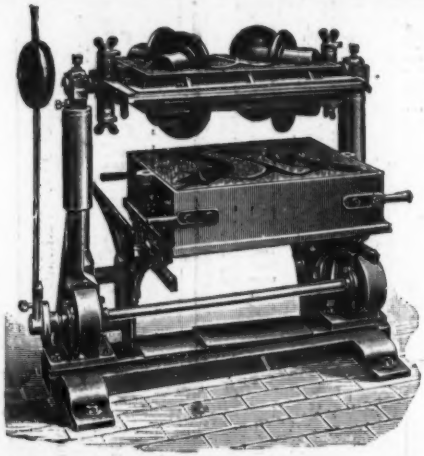

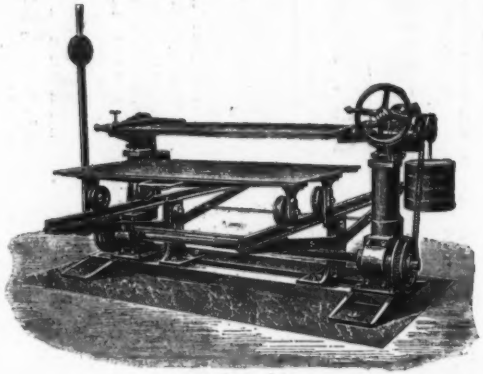

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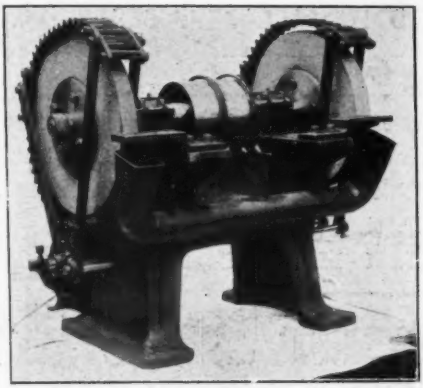

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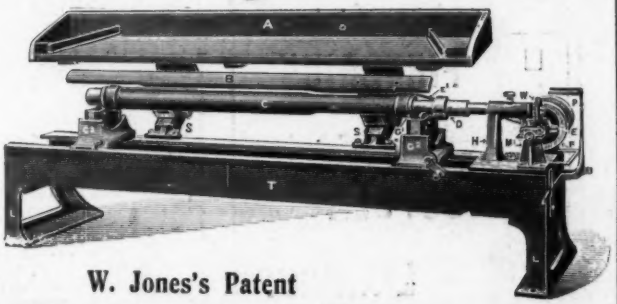

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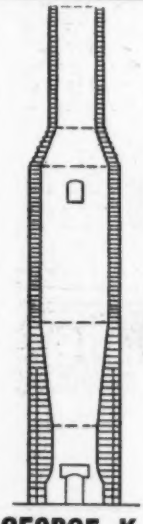

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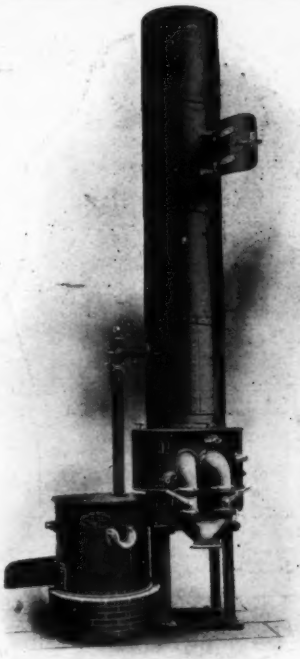

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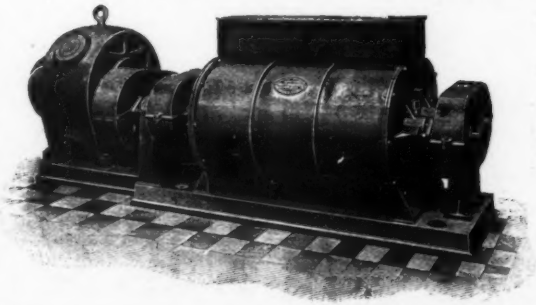

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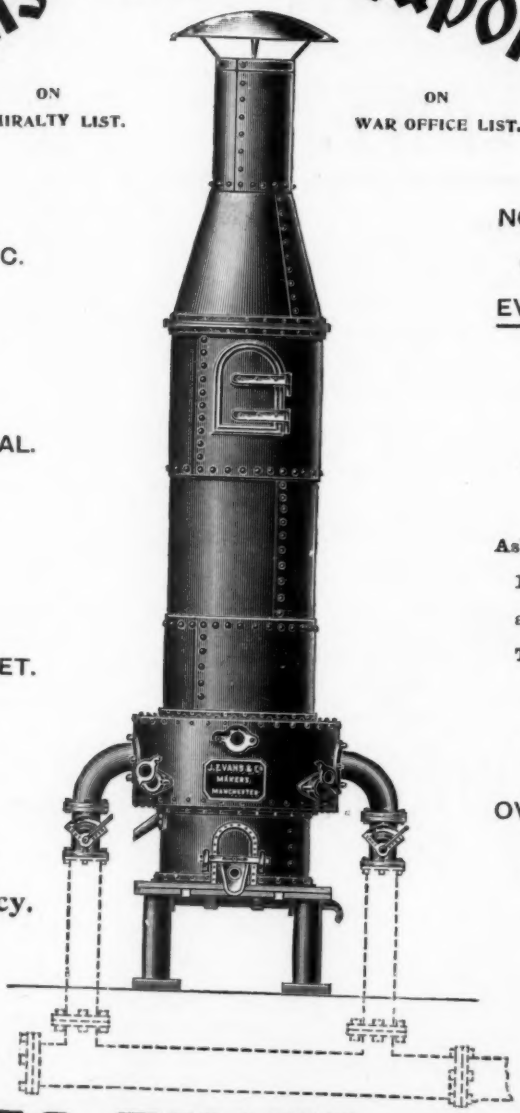

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